DETAILED REPORT

ON

YOUNGSTOWN IRRIGATION EXPERIMENTS

Edited by

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TABLE OF CONTENTS

	Page
Acknowledgements	1
Introduction	3
Report on the soil survey of the Wm. Pearce Irrigation Project - W. E. Bowser	7
Map of the area	14
History of the experiments	15
Details of the experiments	18
Discussion of the results	19
The A plots	20
The B plots	22
Eroded pit experiment	23
The C plots	24
The land levelling studies	24
Survey of special farms, 1953	26
Chemical properties of the soils	27
Water quality	30
Physical properties of the soils	30
Effect of treatments on physical properties	31
Penetrometer studies	32
Consumptive use studies - K. K. Krogman	33
Conclusions	36
Appendix	
A. Details of the A plot experiments	A 1 - A 24
B. Details of the B plots	B 1 - B 19
C. Details of the C plots and other tests	C 1 - C 14
D. The chemical properties of the soils and water	C 1 - D 12
E. The physical properties of the soils	E 1 - E 13
F. Lethbridge data on consumptive use - K. K. Krogman	F 1 - F 6
G. Soil maps	Inside back cover

ACKNOWLEDGEMENTS

The information gathered together here represents the planning, execution, and summarizing of extensive research extending over the period 1950 to 1963. Many individuals have been involved and several institutions. We wish to acknowledge their contribution here.

Dr. O. S. Longman, Dr. J. D. Newton, W. L. Jacobson, and W. E. Bowser were influential in originating the idea of research on the problem of irrigating the hardpan soils of the proposed William Pearce Project. The late Dr. N.H. Grace, as Director of the Research Council, took a keen interest in the research program.

For the initial experiments at Youngstown both the Lethbridge Research Station and the University Soil Science Department established test plots. The former were planned by W. L. Jacobson and K. K. Krogman while the initial University experiments were designed by Dr. J. D. Newton, Dr. J. A. Toogood, and A. L. Mathieu. Messrs. Krogman and Mathieu carried the major load of the direction of the plot work and the development of the experimental program from 1952 onwards. Mr. Krogman remained in charge of the Lethbridge Station's part of the program until it terminated in 1957 and Dr. Mathieu in charge of the University's part until his departure for Tunisia in 1960. Both of these men had the friendly assistance from neighbors Clinton Zinn and Wally Armstrong and the able help over the years of several undergraduate students. Among the latter were: G. H. Anderson, J. A. Goodbrand, W. Haessel, J. Jan, P. Jenson, F. Kannapinn, W. Lund, R. J. Miller, W. K. Opheim, H. Puffer, G. J. Tajcnar, R. L. Thomas, and H. Williams.

We are particularly indebted to Senior students Anderson and Lund who carried the full burden of plot management in 1961 and 1962.

The research program of the Lethbridge Research Station reported here

was summarized by K. K. Krogman. The University's research program was summarized by Messrs. Mathieu, Tajcnar, Lund, and Toogood. Some of the data herein are taken directly from the M. Sc. thesis of A. L. Mathieu and a few details from his Ph. D. thesis. Some of the data on salinity of soils and water were obtained from the P. F. R. A. laboratory at Vauxhall and the help there of R. A. Milne and his staff is gratefully acknowledged.

A major undertaking, relating to the whole Wm. Pearce Project, and affecting the application of conclusions reached in the research program, was the soil survey of a major portion of the potentially irrigable area. This was done by the Alberta Soil Survey and we are indebted to W. E. Bowser, R. A. Milne, A. Kjearsgaard, F. Schroer, and T. W. Peters for the report included here on the soils of the area.

INTRODUCTION

The William Pearce Project, also often referred to as the Red Deer Irrigation Project, has been on the drafting boards for several decades. Following World War II there was an increasing amount of pressure placed on the provincial government to begin development of the scheme. By 1950 soil survey groups of the Canada Department of Agriculture and the Research Council of Alberta were actively engaged in classifying the soils of the area. Under the chairmanship of Dr. O. S. Longman, a committee with broad representation from provincial, federal and university agencies, was meeting to discuss various aspects of the project, - economics, soils, meteorology, engineering, power, land development, recreation, etc. Early reports from the soil survey groups indicated that the soils were not all well suited to irrigation and that in fact a large proportion of them might even be unfit for development.

The crux of the problem was those soils classified as Hemaruka loams which make up about one-third of the project area. Photographs on page 6 show typical profiles of this soil type, and full scale photograph of the hardpan or Bt horizon which is the basic difficulty to be overcome if these soils are to be successfully irrigated.

Subsequent discussions and debate culminated in the following letter from Dr. J. D. Newton, Head of the Soil Science Department to Dr. N. H. Grace, Director of the Alberta Research Council:

December 20th, 1951.

Dr. N. H. Grace, Chairman,
Research Committee,
Department of Agriculture,
Research Council of Alberta

Dear Dr. Grace:

Soil surveys have shown that much of the area of the proposed Red Deer irrigation project has hardpan (solonetzic) soils. In

fact over half of the proposed irrigation area of about 400,000 acres (under the ditch) consists of this kind of soil. Much of it is severely solonized and has a "tough" hardpan and a somewhat salty subsoil. Soils of this extreme character have not been irrigated in Alberta up to the present time, and we have been unable to ascertain that such soils have been successfully irrigated elsewhere. We therefore recommend that before millions of dollars are spent in bringing water to these soils they should be thoroughly investigated.

To this end we recommend that a comprehensive plot and laboratory investigation of these soils be carried out. The object would be, (1) to study the physical and chemical properties of these soils as affected by irrigation and cropping, and (2) to find out if treatment with chemicals such as gypsum and sulphur would improve their physical properties, and (3) to determine whether crops can be successfully grown on these soils under irrigation.

The physical properties of the soil, and especially the physical properties of the hardpan, determine the penetration of water. Physical properties also determine moisture holding capacity. If the soil will not "take" sufficient water it will not be satisfactory for irrigation. Therefore in this investigation the physical properties of the original soil and changes in these properties brought about by irrigation and cropping with grain and deep rooted crops such an alfalfa or sweet clover should be especially studied. The Department of Soils has some special equipment for the study of physical properties, and one member of the staff, Dr. Toogood, is a specialist in soil physics.

A good deal of research work has already been done and published by the Department of Soils on the chemical properties of Alberta's hardpan or solonetzic soils. These soils are rather salty and the kinds and quantities of salts present have been determined, as well as the base exchange properties of the soils. Changes in salt content and base exchange properties brought about by irrigation and cropping should be studied, and the Department is well equipped to carry on these investigations.

The Department of Soils is equipped to carry on special phases of this investigation which can hardly be undertaken by any other existing agency in this province. However, if and field plot investigations are undertaken in this area by the Dominion Department of Agriculture, care will be taken to correlate the work and avoid duplication.

The proposed investigation involving field plot experiments in the Red Deer irrigation district and artificial watering of plots, as well as laboratory investigations can hardly be carried on for less than $3500. per year, and the work should be carried on for three years probably. We are therefore asking the Research Committee to recommend a grant of $3500. in 1952-53 for this research. A tabulated statement of possible costs is attached.

Yours very truly,

J. D. Newton,
Professor of Soils

The funds requested were granted and work began early in 1952. Drs. Newton and Toogood met with Messrs. W. L. Jacobson, K. K. Krogman, and L. G. Sonmor at Lethbridge. It was agreed that experiments would be carried on jointly, with the Lethbridge staff studying consumptive use while the University would concentrate on physical and chemical aspects of the problem.

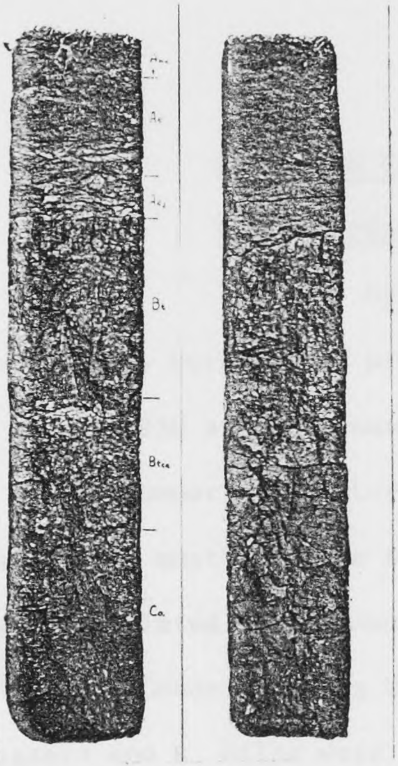
The site selected was in the south-east quarter of 28-28-10-W4 beside a P. F. R. A. stock watering dam. The soil survey staff and the research personnel involved agreed that this site met the following requirements:

(1) The soils were typical of the solonetzic soils which had been mapped in the survey and whose irrigability was questioned.

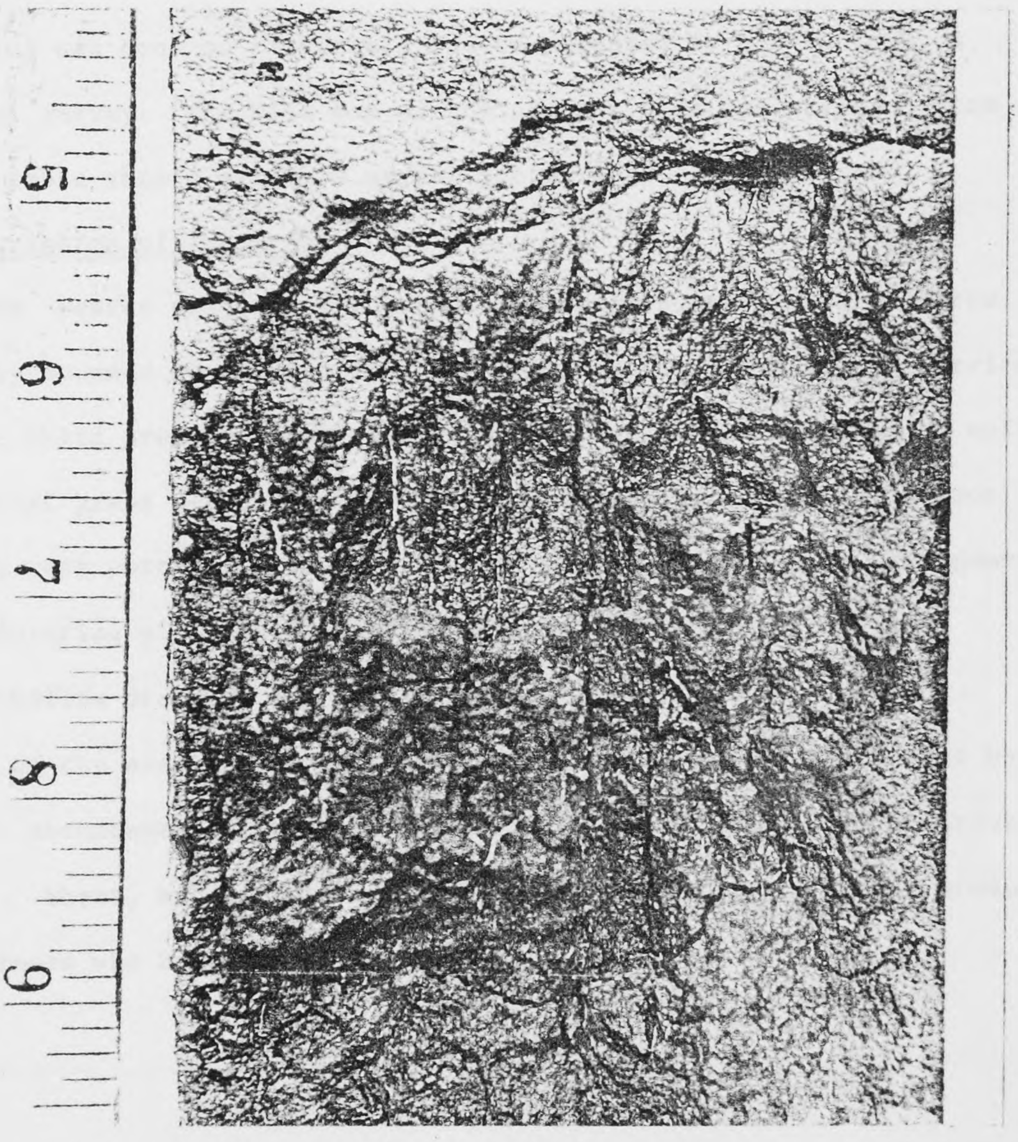
(2) Topography was reasonably suitable and stoniness was no problem.

(3) An adequate supply of water for irrigation was at hand.

The site was selected in May, 1952. Messrs. Krogman, Mathieu and Toogood laid out the initial experimental plots and plowed and worked up the land in time for a late seeding of barley. Irrigation was first applied on July 16, 1952.



Profiles of two Hemaruka loam soils to depth of two feet. The A horizon of the profile on the right is a little deeper than the one on the left. Both have typical hardpan (Bt) horizons. The Bt horizon of the right hand profile is enlarged to full size below.



The hardpan of a Hemaruka soil.

REPORT ON THE SOIL SURVEY OF THE

WILLIAM PEARCE IRRIGATION PROJECT

by W. E. Bowser

Soil survey work on the proposed Wm. Pearce irrigation project was begun in August 1950 and continued through 1951 and 1952. Field surveying was done in the summer, laboratory analysis and map preparation was done during the winter months. This survey was made by the Experimental Farms Service staff assisted by two men from P. F. R. A. and by members of the Alberta Research Council during May and June of 1951. Messrs. F. Schroer, A. Kjearsgaard and R. Milne were in charge of the field mapping units.

Mapping was done on planetable sheets prepared by the P. F. R. A. topographical survey. The base map of the project area was prepared from these plane table sheets and from aerial photographs.

General description of the area

The Wm. Pearce project is located in eastern south-central Alberta. It is roughly bounded by a triangle joining Coronation, Wardlow and Kirriemuir. It is on the third prairie steppe and almost entirely within the brown soil zone (the short grass plains). The elevation varies from about 2550 feet in the north west portion to about 2400 feet on the eastern edge. In general, it is an undulating plain interspersed with a few hilly elevations and relatively shallow drainage courses.

Much of the area was at one time cultivated. However, there has been considerable abandonment. These abandoned farms are reverting to a native grass cover. Wheat, brome grass and cattle are the main agriculture products of those farmers who have remained.

Climate of the area

This climatic report is a brief analysis of the available meteorological data from stations on or near the proposed project. It must be considered as a preliminary review only. The data in this report are presented to (1) give an overall picture of the climate during the growing season and (2) to compare it with the climate of the Lethbridge-Taber area. It is suggested that since we have considerable irrigation experience in the Lethbridge area such a comparison would be advantageous.

The mean average temperature (as estimated from available records) for the area for the period April to October inclusive is 52.5°F. July is the warmest month with a mean average of slightly over 64°F. August is warmer than June. By comparison the mean average for the seven month period for Brooks is 52.5°F. and for Lethbridge is 53.5°F. The mean average for the year is about 36°F. as compared to 41°F. for Lethbridge. That is, the winter months are, on the average, considerably colder in this area than at Lethbridge.

Using a mean daily temperature of 42°F. to begin and end the vegetative season, this area has a vegetative period of about 175 days, as compared with 190 days at Lethbridge. The period begins about April 22 and ends October 15: at Lethbridge it begins about April 12 and ends October 20.

The frost-free period for the area is between 100 and 105 days. By comparison Lethbridge and Brooks have about 115 days and Vermilion (about 90 miles north of Coronation) about 85 days.

There are sufficient elevation differences to cause significant local variations in climate. This would be applicable to both the occurrence of late spring and of early fall frosts.

There are during the April to October period, approximately 60 days in which the maximum temperature is 76°F. or higher, (for the ten-year period

calculated, the variation was from 50 to 80 days). Calculated on the basis of the vegetative season, this is about 1 day out of every 3. For a corresponding period, Lethbridge had 67 days.

The average precipitation for the April to October period is about 10.4 inches. There is a slight decrease in precipitation going from the north-west to the south-east. By way of comparison Brooks and Medicine Hat each receive 9.6 inches and Lethbridge 12.1 for the corresponding period. The total precipitation for the year for the area is about 13 inches. That is about 75 to 80 per cent of the yearly precipitation comes during the 7 month period of April to October.

June is the month of greatest rainfall with an average of about 2.4 inches. Average July rainfall is higher than May. The rainfall peak comes later (possibly by about two weeks) in this area than in the Lethbridge area. This later rainfall peak plus a slightly cooler July temperature as compared to the Lethbridge area would tend to slow the ripening of irrigation crops. Conversely it might reduce the July drought hazard for dry land crops.

During the seven-month period there are between 45 and 50 days with 0.01 or more inches of rain. That is about 1 day out of every 4 or 5. For the corresponding period at Lethbridge there are, on the average, over 55 days with precipitation. In this connection about 15 per cent of the precipitation comes in individual rains of 0.2 inches or less. Most of this is lost in evaporation before it reaches the plant roots.

Insufficient data are available to plot any trends or cycles in the rainfall pattern. There have been periods of extreme drought and periods of near abundant rainfall (the year 1951 was an example of the latter). All that can be said is that there is a tendency for wet years or dry years to bunch

together for relatively short periods. From available records the total yearly precipitation has varied from about 7 inches to 27 inches.

In summary it would appear that the climate of this area is fairly good to good from the viewpoint of growing cereal and legume crops under irrigation; rainfall is low, summer temperatures are fairly high and high winds are relatively infrequent. Compared with the Lethbridge-Taber area, however, it has a somewhat shorter growing season: this would mean less specialty crops.

Geology

The underlying bedrock in the mapped area is Bearpaw Shale (Upper Cretaceous). This is a dark, somewhat saline, marine shale having a very high clay content (Belly River bedrock underlies the extreme North east corner).

The entire area, however, has been glaciated by the Keewatin ice sheet. This ice sheet in passing over the area from north to south left a mantle of glacial drift over the original bedrock. This drift varies considerably in thickness, but in general is not deep. The material in this drift sheet is composed of Bearpaw shale mixed with some material of Belly River origin. Consequently this glacial material is of a clay loam to clay texture and contains considerable salt.

There has been considerable post glacial sorting in this area; mainly by stream action. As a result, there is a fairly large acreage of light textured soils in the area. These soils are concentrated mainly along Berry and Sounding Creeks.

Soils

In general, the soil types mapped can be divided into two main groups. The light textured soils, mainly of alluvial and aeolian origin, and the

solonetzic soils formed on the sorted till plain. The following table summarizes the soil data.

Conclusions

In summary it may be said that certain problems will have to be overcome in the irrigation of this area. One of these is the irrigation of very slowly permeable Hemaruka soils that occur on sloping land. Preliminary field percolation studies indicate a rapid penetration of the loose surface horizon by water. Both horizontal and lateral movement of water through the subsoil horizons is very slow and the hydraulic conductivity often approaches zero. Also the high concentration of salt in the lower horizons of the Hemaruka soils may affect the growth of some of the less tolerant crops. There does not appear, as yet, to be any way to remove or neutralize these salts.

Seepage will occur in the lighter textured area of Youngstown and Cavendish soils. It is quite possible that there will be a fairly high loss of acreage as a result of this seepage. This loss should be materially reduced although not eliminated, by providingdrainage from the very beginning.

Very little ideal topography exists throughout the project. This means (1) considerable levelling must be done, (2) fields will be irregular and possibly small, (3) few quarter sections will have over 2/3 topographically irrigable land, (4) seepage spots will occur with a fairly high frequency and (5) erosion could be a problem.

Due to the somewhat shorter growing season there will be a limited number of crops that can be satisfactorily grown. Grass and legume hays however should be among the suitable crops. This is important since there is considerable dry pasture land adjacent to the proposed irrigable areas, and it would appear that livestock must play an important role in the development

of the area.

The area covered by the soil survey takes in the main portion of the proposed project. Small patches of irrigable land do occur east of the mapped area. Some of these could be developed if desired.

INVENTORY OF SOILS OF THE WILLIAM PEARCE PROJECT

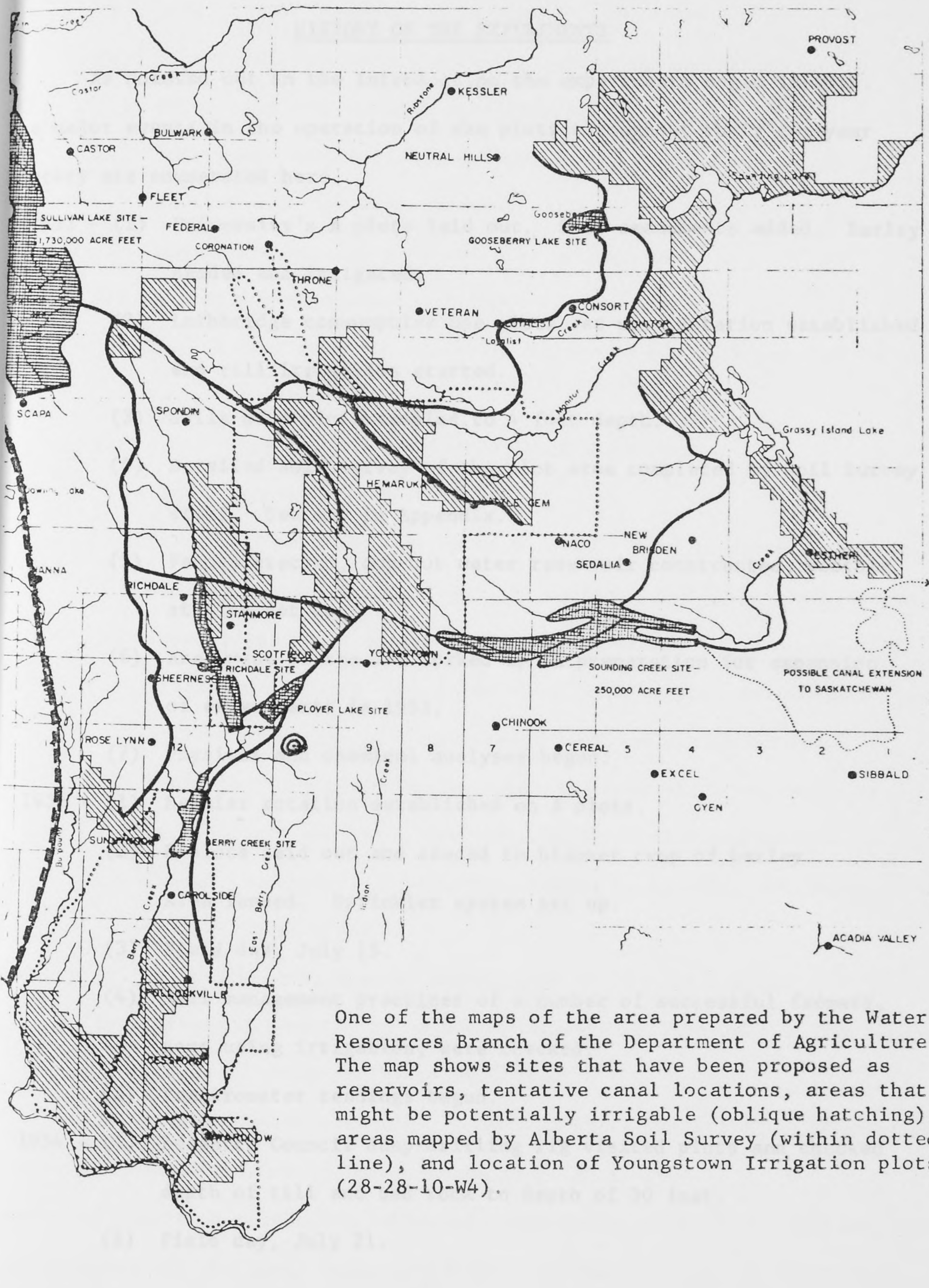
Soil	Sub Group	Acreage	Remarks*
Soils Developed on Alluvial - Aeolian Material			
Dune Sand S.	Rego Brown	27,200	Dune topography, poor soil
Cavendish loamy fine sand and fine sandy loam Cd. LFS. & FSL.	Orthic Brown	52,000	Till at 6 to 8 feet. Seepage probable. Fair to fairly good irrigation soil.
Sunnybrook loamy fine sand and sandy loam Sn. LFS. & SL.	Orthic Brown	25,400	Till at 2 to 4 feet, will form temporary water tables. Poor to fair irrigation soil
Wainwright loamy sand Wn. LS.	Orthic Dark Brown	3,000	Similar to Cavendish Fairly good irrigation soil
Metiskow fine sandy loam Met. FSL.	Orthic Dark Brown	800	Similar to Cavendish Fairly good irrigation soil
Sullivan Lake loamy sand and fine sandy loam Sul. LS. & FSL.	Dark Brown Solonetz	1,900	Saline, impermeable horizon within 2 feet. Poor irrigation soil
Youngstown loamy fine sand and fine sandy loam Yt.LFS. & FSL.	Brown Solodized Solonetz	48,200	Some salinity, some poorly drained areas. Poor to fairly good irrigation soil
Chin silt loam Ch. SiL.	Orthic Brown	700	Very good irrigation soil
Wardlow silt loam Wd. SiL.	Brown Solodized Solonetz	300	Saline with a very slowly permeable B horizon. poor to fair irrigation soil

* Suggested rating does not take topography into account.

Soil	Sub Group	Acreage	Remarks
	Soils Developed on Gravelly Outwash Material		
Collard sandy loam and loam C. SL. & L.	Orthic Dark Brown	11,700	Value depends on depth of profile overlying the gravel. Poor to fair irrigation soil
Chaplin sandy loam and loam Ch. SL. & L.	Orthic Brown	5,500	Value depends on depth of profile overlying the gravel. Poor to fair irrigation soil
	Soils Developed on Recent Alluvial Deposits		
Alluvial clay Av. C.	Rego Brown	8,700	Slow to very slow infiltration. Fair to fairly good soil
Alluvial clay (Saline) Av. C. (Sa)	Saline Regosol	18,800	Depressional areas, saline. Non-irrigable.
Scotfield sandy clay loam Sf. SCL.	Solonetz		
	Soils Developed on Glacial Till		
Maleb loam Mb. L.	Orthic Brown	6,500	Good irrigation soil if on level to gently undulating topography
Hemaruka loam Hu. L.	Brown Solodized Solonetz	140,000	High SAR and very slowly permeable B Horizon; A horizon eroded in spots Poor irrigation soil
Halliday loam Hd. L.	Brown Solod	8,000	Fair to fairly good irrigation soil
Halkirk loam Hk. L.	Dark Brown Solodized Solonetz	14,400	Characteristics similar to Hemaruka. Poor irrigation soil
	Soils Developed on Modified Shale		
Torlea clay Tl. C.	Dark Brown Solonetz	1,800	Subsoil relatively impermeable. Non irrigable soil
		374,500	

(Note - A copy of the soil survey map may be found at the end of the Appendix.)

Map of the Area



One of the maps of the area prepared by the Water Resources Branch of the Department of Agriculture. The map shows sites that have been proposed as reservoirs, tentative canal locations, areas that might be potentially irrigable (oblique hatching), areas mapped by Alberta Soil Survey (within dotted line), and location of Youngstown Irrigation plots (28-28-10-W4).

HISTORY OF THE EXPERIMENTS

As pointed out in the Introduction the experiments began in 1952. The major events in the operation of the plots throughout their ten-year history are enumerated here.

1952 - (1) University's A plots laid out. Soil amendments added. Barley seeded and irrigated.

(2) Lethbridge consumptive use plots set up. Rotation established and rill irrigation started.

(3) Soils of A plots sampled to 4 foot depth.

(4) Detailed soil survey of the plot area completed by Soil Survey staff. See map in Appendix.

(5) Fences erected, dug-out water reservoir constructed, weather station set up.

(6) Area west of the dam worked up in preparation for expansion of experiments in 1953.

(7) Physical and chemical analyses begun.

1953 - (1) Regular rotation established on A plots.

(2) B plots laid out and seeded to blanket crop of barley. Area fenced. Sprinkler system set up.

(3) Field day, July 15.

(4) Soil management practices of a number of successful farmers, some using irrigation, were checked.

(5) Penetrometer readings begun.

1954 - (1) Research Council deep-drilling rig visited plots and checked depth of till and bed rock to depth of 30 feet.

(2) Field day, July 21.

(3) Small header constructed to harvest plot samples.

(4) Land levelling plots planned by Lethbridge personnel.

1955 - (1) First crop year on land levelling plots.

(2) Some sugar beet seedings attempted on a small scale.

1956 - Regular experiments continued.

1957 - (1) Amendments applied a second time to A plots.

(2) Eroded pit experiment planned.

(3) Severe hail storm on August 11 destroyed 50 to 75 per cent of the crop.

(4) Lethbridge Station terminated their experiments.

1958 - (1) Eroded pit experiment laid out.

(2) Dry land test plots set up on C. Zinn's farm to check on effectiveness of attachment, designed by A. L. Mathieu, for Noble blade weeder.*

(3) Some winter wheat seedings on dry land tried.

1959 - (1) Attempted seedings of crested wheat, tall wheat, and slender wheat grasses on strips of virgin range land and slough bottom.

(2) Land levelling plots seeded down to forage mixtures, north half to be irrigated and south half dry, using recommended species.

(3) Seeded consumptive-use-of-water ranges I, II, III, and IV to crested wheat grass.

1960 - (1) Applied manure, gypsum, sulphur and krilium to A plots.

(2) Carried out survey of adjacent farms to collect data on dry land yields of wheat on fallow 1953-1960.

(3) Interim report presented to Special Areas Investigation Commission. Dated October 13 and prepared by J. A. Toogood.

* Separate report on this study published. See paper by Dr. A. L. Mathieu "Chisel attachments for the blade cultivator", Can. J. Soil Sci. 41: 81-85. 1961.

(4) Range VIII of consumptive-use plots plowed and laid out for C plots, an experiment to test several amendments not included in A plots.

1961 - (1) Began final compilation of data.

(2) A, B, and C plots and land-levelling plots continued.

1962 - (1) Final year of experiments. Crested wheat seeded with grains on all plots.

(2) Camp closed down. Lethbridge property returned to Vauxhall. Research Council property (trailer, tractor, machinery, etc.) moved to University's Ellerslie Farm. Garage sold to C. Zinn.

DETAILS OF THE EXPERIMENTS

For the sake of clarity the data on each experiment have been gathered together and placed in one section in the appendix of the report. There the reader will find in the beginning of each section a description of the treatments selected, a plan of the plot lay-out, and the detailed data pertaining to the experiment. Each section concludes with tables summarizing the data. The sections of the Appendix have been organized as follows:

Appendix A	-	The A plots.	Pages A 1 - A 24
Appendix B	-	The B plots	Pages B 1 - B 19
Appendix C	-	The eroded pit experiments) The C plots) Survey of dry-land yields) Land levelling studies) (a) Lethbridge 1954-1957) (b) University 1958-1962) Survey of special farms)	Pages C 1 - C 14
Appendix D	-	The chemistry of the soils and water	Pages D 1 - D 12
Appendix E	-	The physical properties of the soils	Pages E 1 - E 14
Appendix F	-	Lethbridge report on the consumptive use plots	Pages F 1 - F 6
Appendix G	-	Soil survey maps (1) Northern part of project (2) Southern part of project (3) Youngstown plots	(In pocket on back cover)

DISCUSSION OF RESULTS

In examining the data for the Youngstown experiments one should keep in mind the levels of production achieved elsewhere in Alberta on irrigated land. Rotation "U" at the Lethbridge Research Station for example provides some data on irrigated crop yields that can be compared in a general way with the yields on the Hemaruka soils. The following table appears in the report to the Alberta Advisory Fertilizer Committee for 1962.

Crop Yields on Rotation "U"

(Cereals in bushels, hay and sugar beets in tons, per acre)

Crop	Treatment	Fertilized 30-yr. av. 1933-1962	Non-fertilized 52-yr. av. 1911-1962
Barley		80.3	70.2
Oats		110.6	100.7
Alfalfa 1	100 lb. 11-48-0	2.96[1]	2.26[1]
Alfalfa 2		2.71[1]	1.50[1]
Alfalfa 3	15 tons manure	1.93[1]	1.21[1]
Sugar beets	100 lb. 11-48-0	19.20	16.19[2]
Wheat		58.5	54.3
Alfalfa 1a	100 lb. 11-48-0	3.13	2.52
Alfalfa 2a	15 tons manure	3.78	2.89
Alfalfa 3a		3.38	2.99

[1] Average yields following revision in 1951

[2] 40-year average.

It must be admitted at the start that the management of any soil improves with experience. Undoubtedly yields on the Youngstown irrigation

plots could have been better in the early years if better techniques had been used. Tilling solonetz and solodized-solonetz soils below or above a critical moisture level for example results in impairment of structure. Soil moisture is vital at seeding time, not only for germination, but to prevent crusting which can occur and seriously reduce emergence. Counteracting such factors as these however in the early years of the experiments there were two or three seasons with above normal rainfall. The yields from the Youngstown plots should therefore be a fairly reliable indication of what a farmer might expect if he were to attempt to irrigate such soils over a period of years.

The A plots

Pages A 2 and A 3 give the treatments and plan of the experiment.

Page A 19 gives the complete summary of yields on these plots. The highest single yield of wheat recorded was 45.0 bu./ac. in the manure plots of block C of the 2-year rotation in 1958. In 1956 these same plots averaged 41.9 bu./ac. These are the only figures in the entire table exceeding 40.0 bu./ac. About one-quarter of the yields on irrigated plots are in the 30.0-39.9 range and over one-half of them are in the 20.0-29.9 range. These yields for fertilized and irrigated wheat are not encouraging when compared with the Lethbridge yields of 54.3 and 58.5 bu./ac. referred to above. While the Lethbridge yields occurred in a 10-year rotation including six years of alfalfa there could be no fertility problem at Youngstown because commercial fertilizers were used annually.

The object of the A plots was to test the value of amendments. All those used appeared to have helped to some degree, sulphur increasing average yields of wheat 5.0, krilium 3.2, gypsum 5.9, and manure 8.2 bu./ac.

The costs of the chemicals however would be prohibitive in achieving these relatively small improvements in productivity. Manure was the only practical amendment. Deep cultivation brought a 2.5 bu./ac. increase. The use of sweet clover in rotation with wheat helped to the extent of 4.1 bu./ac. (See page A 18). The sweet clover yields were low and even with the best treatment, the manure application, amounted to only 1.2 tons per acre.

The yields of the dry plots were of course much lower than the irrigated plots and compared reasonably well with dry-land yields obtained on adjacent farms. This was checked for the years 1953-60 and is reported on page C 5.

One of the major problems emphasized by the data is the extreme soil variability. This is well illustrated in the photographs on A 5 and further indicated by the varying growth of native vegetation (page A 4) and the crops of barley in 1952 (page A 21), wheat in 1953 (page A 22) and wheat in 1956 (page A 23). The differences in quality of the grain produced is indicated by the wide range of protein content found in samples from blocks B and C in 1960. (See page A 24).

The attempt made to correlate the 10-year average wheat yields with original cover (page A 20) is not conclusive. The highest yielding plot was III M, whose original cover was mostly heavy buck brush (<u>S. occidentalis</u>). The dark patches of soil in the centre photograph on page A 5 indicate the location of stands of buck brush. The soil in these spots was friable, of good structure, and lacked the conspicuous hardpan of adjacent soil profiles. One might ask whether the buck brush was the cause or the result of this desirable soil tilth. A study of other plots on A 20, even taking into account that the sample was always a three foot strip

along the centre of the plot, shows no conclusive relation between yield and original cover.

The B plots

See pages B 2 and B 3 for the treatments and plan of the experiment.

The variability in the soil was again a conspicuous factor in crop production. The barley crop, planted as a uniformity trial in 1953, received adequate rainfall to produce a good stand where the soil was suitable. There were several spots however where there was no crop (see page B 6) and many areas where growth varied from a few inches in height to as much as two feet. Page B 18 shows another check on variability of the soil as indicated by the heights of the wheat and oat crops in August, 1956.

An annoying aspect of experiments located on such variable soils is the difficulty of distinguishing effect of treatment from effect of soil. Replication is supposed to take care of this but a glance at the yields for any one of the treatments for any one of the nine years (page B 7 - B 15) will show that there was very little agreement among the four replicates. Statistical analyses of the data nearly always showed no significant differences between treatments whether on irrigated or on dry-land plots. When the data for the nine years are combined however an important conclusion appears to be warranted.

The nine-year summary for irrigated B plots is on page B 16. Whether we examine the averages for wheat in rotation or continuous wheat there appears to be no doubt that deep plowing was effective, increasing yields from 23.2 to 32.9 in rotation and from 14.5 to 23.0 in the continuous plot. Oats also profited, yields increasing from 39.5 to 57.7. The sweet clover in rotation likewise grew better on the deep plowing plot, producing 0.4

tons per acre more. The deep cultivation was almost as effective as the plowing.

Three questions immediately arise if we accept the conclusion that deep plowing is desirable. Would the heavy initial cost of a deep plowing operation be economical, coupled with other costs of installing an irrigation system? Are the gains, which appear to be within reach, large enough and the final productivity of the soil high enough, to warrant the time and costs? How often would deep plowing need to be done?

Included in the objectives of the B plots was the hope of finding out if alfalfa would open up the hardpan and result in good yields of wheat. Accordingly 3-year and 4-year stands were plowed under in 1956 and 1961 respectively (treatment "A" on page B 3) and seeded to wheat in 1957 and 1962. The crops were poor (see B 19) and certainly not as good as the deep tillage treatments. There is a possibility however that the alfalfa residue had not had time to decompose properly as the wheat crops showed definite deficiency symptoms. The alfalfa should have been plowed under earlier than it was.

Eroded pit experiment

This exploratory test (see page C 2) aimed to check the effectiveness of a number of chemicals in breaking up the hardpan or improving plant growth. Rates of application were high, similar to those used later in the C plots (C 3). Even the eroded pits however proved to be variable and replications of given treatments failed to agree closely. In many of the plots crusting was so severe that emergence was prevented and wheat yields thus affected. However the effectiveness of $CaSO_4$ is worthy of note and agrees with the success of gypsum on the A plots. The possibilities of alum and manganese having a desirable effect were of interest. Rates of application were of

course totally impractical. It must be realized that the exact nature of the cementing forces in the hardpan layer has yet to be discovered. Most current theories attribute them to a combination of type of clay mineral, organic compounds and suite of cations on the exchange complex. The introduction of humus or humic acids and their beneficial effect on soil aggregation account for the value of manure as a supplement to these soils and explain why coal was used as an amendment.

The C plots

These were a sort of all-out assault on the problem. The treatments, shown on page C 3, coupled every conceivable chemical amendment with liberal applications of a variety of commercial fertilizers. But the stand of wheat on these plots in 1961 showed more variability due to soil than to any of the applied treatments. Differences between replicates were so great that the increases over check shown on pages C 3 and C 4 cannot be relied on as significant differences. It was hoped that a second crop, in 1962, would add more weight to this experiment and give some conclusive data but the test was ruined by range cattle getting into the plot area.

The land levelling studies

Details of the tests are given on page C 6.

The degree of difficulty in levelling this two-acre area of Hemaruka soil may be gauged by comparing the topographic maps on pages C 8 and C 10 and by noting in the table on C 9 the number and locations of grid points where cuts or fills in excess of 0.5 foot were required. Added to the fact that the soils in the eroded pits when dry are extremely hard and compact, and would be difficult to pulverize for a smooth levelling job, the uneveness of the topography in such a small area shows that levelling here for flood irrigation would be a painstaking process. There is also the problem that the Ah horizon varies from none at all in the eroded pits

to six inches or more in between them. The fact that the pits are not all at the same elevation would make the uniform spreading of the Ah horizon difficult if not impossible. The importance of this Ah horizon however from the fertility point of view and the effect of cutting and filling on crop production are not large. See pages C 9 and C 11 where, although a tendency for fill areas to outyield cut areas is indicated, the differences in productivity are not large compared to overall variations. The outstanding feature of the yield data is their wide variability, the green weights of oats in 1955 varying from 0.20 to 5.67 tons per acre and the yields of barley in 1956 varying from 7.8 to 80.8 bu./ac. Obviously the levelling process did not result in a uniform soil.

The University's experiments on the land levelling plots were aimed to gauge the forage-producing potential of this soil under irrigation compared to dry-land production. The recommended mixture of brome, creeping red fescue, orchardgrass and White Dutch clover was seeded in 1959 on the half of the plots to be irrigated and some reseeding was done in 1960. In 1961 at time of sampling brome dominated the mixture with less than ten per cent of the other grasses and clover present. Yields (C 12) were again extremely variable but averaged 2.4 tons of mature grass hay. The crested wheat, tall wheat, and slender wheatgrass mixture seeded in 1959 on the dry half of the land levelling plot was, by 1961, almost a pure stand of crested wheat. The yields (C 12) averaged 0.92 tons per acre, which is estimated at more than double the yield of forage on the adjacent native range land.

The 1962 crop of wheat on the irrigated half of these plots was the eighth year of cropping following the initial land levelling. The

yields (C 12) varied from 17.7 to 48.1 and averaged 30.7 bu./ac. The variability observed in the oat crop of 1955 had not disappeared by 1962 but showed some signs of being reduced. Thus, while green oat yields in 1955 varied from 0.20 to 5.67 tons per acre, a 28-fold spread, the wheat yields of 1962 varied only from 17.7 to 48.1 bu./ac., a 2.7-fold spread. This tendency for stand of crop to become more even on particular plots over the years was also observed on A and B plots.

Report on survey of special farms, 1953

For details see pages C 13 and C 14.

Representations from local Chambers of Commerce and Irrigation Associations to the government made two claims which must be refuted. The first was that a group of successful farmers were, by 1952, already successfully farming the problem Hemaruka soils. A specific list of their names was provided. The survey made by Dr. A. L. Mathieu of the farms referred to showed that only two of the nine farmers were irrigating the Hemaruka soil (Page C 14). One of these irrigated "5-10 acres of pasture land and a garden" while the other irrigated "alternate 20-acre fields each year" and found that the soil became very hard and impervious after irrigation. Claims that the E.I.D. was already successfully irrigating similar soils in the Tilley area must likewise be refuted since soil surveys have shown that the major portion of the soils in the Tilley area are eluviated chernozems and weakly developed solods. Both have much more permeable subsoils and are less saline than the Hemaruka soils.

The second claim which must be examined carefully is the one that the plots were located "on one of the poorest pieces of land in the district" and not "a true average of the lands to be tested". An examination of the soil survey map of the project area shows that 25 different soil types were

were recognized in the 374,500 acres mapped. Only 8 of these soil types, with an acreage totalling 79,700, were classified as fair to good irrigation soil, and this did not take topography into account. Of the remaining 294,800 acres the survey mapped 140,000 as Hemaruka loam. This soil type, occupying the large acreage that it does, comprises 37 per cent of the surveyed area, makes up the major portion of the irrigable area, and is at the bottom of the list as far as irrigability is concerned. It was essential that this poorest soil receive attention. Could it be irrigated successfully? Was there any way of overcoming its inherent problems of low permeability and salinity?

As to the particular site chosen one must have confidence in the soil surveyors. These men have travelled over every road allowance in the area, dug and examined the profiles of soils in every section of land, in every township. When soil surveyors agree then that the site selected was typical of the Hemaruka loam soil type occurring in the William Pearce project their word must be accepted. One might argue that a particular soil type covers a range of characteristics and that the site selected was near the bottom of the range as far as irrigability is concerned. As the experiments have demonstrated however the soil is so variable over even an acre or two that it is doubtful if this criticism could be upheld.

The chemical properties of the soils

For details of analyses see pages D 1 - D 10

The chemical analyses of the Youngstown plot soils centred around various aspects of their salinity. Little attention was given to their nutrient content since it was known that lack of fertility was a problem easily overcome. Being in the Brown Soil Zone these soils could be expected to respond under irrigation to applications of nitrogen and phosphorus and in all the tests commercial fertilizers were used at recommended rates

to make up for any deficiencies.

The major task, in terms of soil chemistry, was to assess the salinity hazard in the Hemaruka soils. The U. S. D. A. Handbook 60 was the basic reference which guided the analyses and provided criteria for classifying the soils as to the seriousness of their salt problem.

One of the standard tests for salinity is the measurement of the conductivity of an extract from a saturated soil sample. Conductance is measured in terms of millimhos per centimeter and readings are directly related to soluble salt content of the soil. Readings of conductivity are classified in Handbook 60 as follows:

0 - 2	-	Salinity effects mostly negligible
2 - 4	-	Yields of very sensitive crops may be restricted
4 - 8	-	Yields of many crops restricted
8 - 16	-	Only tolerant crops yield satisfactorily
16 -	-	Only a few very tolerant crops yield satisfactorily.

With this scale in mind we may examine the conductivity of the A plot soils. (See page D 2). Of 21 surface foot samples only 3 tested less than 2 mmhos. while 10 tested over 4 mmhos. In the second foot of soil 14 out of 21 tested over 4, in the third foot 15 out of 21, and in the fourth foot 18 out of 21. Only one plot out of the 21 could be said to have negligible salinity.

The salinity measurements of the B plot samples were made using an older procedure but results (page D 3) indicate the same salt hazard as in the A plots. Here about 10 per cent of the 80 plots were relatively salt-free.

Krogman and Milne compared the salinity characteristics of three soils: non-irrigated Hemaruka, irrigated Hemaruka, and irrigated Halladay (page D 4).

Their data place the Hemaruka soil in the Handbook 60 category of saline-alkali soils while the Halladay soil, top two feet only, would rate as non-saline and non-alkali. Their study emphasized however that these soils occur in such close association in the field and the sub-soils are so rich in soluble salts that irrigation would only aggravate the situation by

(1) Moving soluble salts from the Hemaruka to the Halladay, and

(2) Bringing soluble salts up from the subsoil to the surface by evaporation.

The element sodium, when in the cation exchange complex of clay minerals, is particularly injurious to soil structure. It leads to break down of aggregates and to excessive swelling of clays, and hence the calculation of SAR values (sodium adsorption ratio) which relates the amount of sodium present to the other major cations calcium and magnesium. Dr. Mathieu's data (page D 5) show how much worse the Hemaruka soil is, compared to the Echo and Trossachs series, with respect to the relative amounts of sodium.

Pages D 6 - D 9 give a detailed analysis of the exchangeable cations in all 84 of the A plots, surface foot only, in 1952 and again in 1959. A summary appears on page D 10. For various reasons the methods of analysis used in the two years were not identical, particularly as they applied to measurement of Ca and Mg. The tendency was to get higher values for these two exchangeable cations in 1952, when the Versene procedure was used, compared to the flame photometer data of 1959. As percentages of the total exchange capacity however, the data for the two years are comparable. The data for the individual replicates (pages D 6 - D 9) show wide variations and no indication that any of the treatments had any effect on the exchange complex. One might have expected exchangeable H to increase where sulphur was added, and Ca where gypsum was added. The figures give no hint of such a change. To remove excess sodium from a soil one must not only apply gypsum (or some

other source of calcium) but also provide drainage so the sodium displaced can be flushed out. No drainage was possible on the Youngstown plots so it is perhaps not surprising that there were no marked changes in the exchange complex in this 7-year period.

Water quality

Data are presented on pages D 11 and D 12

The following observations appear to be warranted relative to quality of water used in the experiments:

(1) The water in the P. F. R. A. dam was similar in quality to that being taken from reservoirs for irrigation in the E. I. D., B. R. D. and S. M. R. D. areas of southern Alberta.

(2) Most waters being used in Alberta have a reasonably low sodium hazard but contain enough salts in solution to be classified as "medium salinity water" by the U. S. D. A. Handbook 60. The Handbook states that such water "can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control".

(3) Using Red Deer river water, water class C 2 S 1, to irrigate soils so high in soluble salts as the Hemaruka series would be inviting trouble unless elaborate means were to be taken to provide leaching.

The physical properties of the soils

Data appear on pages E 1 - E 14

There is not doubt that certain physical characteristics are the dominant faults of the Hemaruka soils. What are these characteristics?

(1) Wide variability in texture (page E 4) which results in a wide range in infiltration rates, hydraulic conductivity, structure and moisture holding capacity.

(2) A high percentage of clay and silt in the Bt horizon, associated with and causing the hardpan condition. See page E 5, and photos on page 6 .

(3) While the hydraulic conductivity of the friable Ah horizon is quite satisfactory, that of the Bt horizon is frequently close to zero. See pages E 6 and E 7.

(4) The soils are poorly aggregated, especially in the Bt horizon as indicated by the low total porosities and low mean weight diameters. Also, the stability of aggregation is extremely variable. Pages E 8 and E 9.

(5) Penetrometer studies showed large variation in depth of isoprobes, indicating wide differences in compaction and moisture content of the soils.

Effect of treatments on physical properties

The purpose of adding amendments to the A plot soils was to produce a better soil structure. By measuring the stability of aggregates in 1953 and again in 1959 we hoped to be able to demonstrate some success in this regard. Results were disappointing (page E 8, E 9). In the 1953 analyses the only treatment which had altered mean weight diameter was krilium. This was effective in improving yields but would be impractical because of the high cost of the chemical. It does support the contention however that improvements in structure in this soil will boost productivity.

By 1959 some of the other treatments appear to have borne fruit. Compared to the irrigated check plot the krilium, manure, and sulphur treated areas all had larger stable aggregates. Average yields from these plots was not well correlated however with mean weight diameter as shown in this tabulation:

Treatment	M. W. Diam. '59	Yield '53-'62
K	1.16 mm.	27.0
M	1.11	32.0
S	1.09	28.8
DC	1.06	26.3
G	1.02	29.7
IC	1.00	23.8
Dry	0.82	6.6

Penetrometer studies

The nature and purpose of the penetrometer work is discussed on page E 10.

The isoprobe curves on E 11 probably indicate fairly accurately those soil profiles with a well-developed hardpan since at these points the isoprobe is at a depth of one foot or less. Where the isoprobe is from two to four feet below the surface it is likely that no hardpan is present. Variations in the isoprobe curves must also be due to the differences in texture and structure already referred to and to consequent differences in moisture content. The fluctuations in these isoprobes indicate as well as if not better than any other data gathered concerning these plots the extreme variations in the soil over very short distances.

Examination of the graph on page E 12 reveals effects of treatments on isoprobes over the 7-year period 1953-59. If any of the treatments had a mellowing effect on the hardpan then isoprobes for these treatments should have been deepened over the period. The June readings show this was the case for the krilium and gypsum treatments but not for the manure treatment. The September readings reverse the picture. In spite of the large number of replications therefore it is difficult to put confidence in the differences portrayed. The September readings were much less than the June readings only because the soil was dried out, but if this is true it is not clear why the "Dry" plot isoprobes in June were as deep as those for the "Irrigated check" plots.

On page E 13 the B plot isoprobe data are summarized. Here a few conclusions appear to be justified:

(1) Deep cultivation and deep plowing loosened the soil to a depth of 20 inches and the effect lastedfrom the time of the operation in 1953 until 1959, at least on the irrigated plots.

(2) Isoprobes in the irrigated plots were about four inches deeper than in the dry plots.

(3) With regard to the alfalfa and crested wheat plots, these perennial crops probably resulted in a drier soil, thus accounting for the shallow isoprobes.

(4) The deep plowing isoprobe average on the irrigated plots is deepest and probably indicates the most effective job of destroying the hardpan in all the Youngstown plots.

<u>Consumptive use studies by Lethbridge Station</u>

(Discussion provided by K. K. Krogman)

The May-to-September precipitation varied considerably from year to year (see page F 3). The totals for 1952, 1955 and 1957 were similar to the 1932-1941 average of 7.64 inches which was recorded at a farm* near Youngstown and in line with the figures shown for Hanna. The 1930's are usually considered to have been dry years; thus half of the years of the present study may be considered as normally dry. In 1953, 1954 and 1956, precipitation was considerably higher, but not always favorably distributed over the growing season. Except in 1956 when both evaporation and rainfall were high, evaporation from a free water surface at ground level appeared to be inversely proportional to rainfall.

Yields and corresponding consumptive use of water for the growing season are given on pages F 4 - F 6. The yield data are averages of those obtained for the range of soil conditions which existed on the plots, as well as being averages for the particular number of replicates used. Although soil type greatly influenced yields, substantial yield responses to irrigation were obtained in all years except 1956, when rainfall was ample and timely and high yields were obtained on the non-irrigated plots.

* Canada Department of Agriculture, Illustration Station.

Details of the effect of soil type in these plots have been published elsewhere by Krogman and Milne.* The Halladay soil series in 1955 and 1956 produced yields of wheat, oats, and barley of 48.0, 97.0 and 59.3 bu./ac. respectively while the Hemaruka soil series produced only 25.1, 59.6 and 31.3 bu./ac. Yields of wheat on the consumptive use plots are in general slightly better than on the University's A plots for the same years. This may be accounted for by a larger proportion of Hemaruka soils in the A plots. This can be seen by examination of the soil survey map of the plots in Appendix G.

From 2 to 5 irrigations were required on the consumptive use plots during the growing season to produce maximum yields, the number depending on the frequency and amount of rainfall. In the drier years, irrigation water had to be applied as frequently as every 10 days to supply the moisture needs of the crops.

The solod (Halladay soil) produced maximum yields with from 3 to 4 irrigations during a normally dry summer. To attain maximum yields on the solodized-solonetz soil (Hemaruka) 6 or more irrigations during the season were required. Furthermore, even with frequent irrigation, the yields obtained on the Hemaruka soil were not larger than the non-irrigated crop yields on the Halladay soil.

Individual applications ranged from 0.5 to 2.5 inches depending on the predominating soil type on the plot and its dryness before irrigating. Because of the low infiltration rates on most of the plots, irrigation water could not be applied faster than about 0.5 inch per hour. It was found that if this rate of application was exceeded, excessive ponding would occur. Also, excessive water erosion tended to occur if irrigating streams

* Krogman, K.K. and R.A. Milne. 1961. Suitability for irrigation of a solonetzic soil complex in east-central Alberta. Can. J. Soil Sci. 41:188-195 .

were too large. Slopes greater than one per cent appeared critical in this respect. The maximum yields of cereals were satisfactorily high but the yields of forage crops, particularly the pasture mixture were low. Although the poor yields of forage crops were likely due to low fertility and adverse physical conditions of the soil, there was little or no fertilizer response. Of all of the crops in the study, oats and barley appeared to respond the most to fertilizer, particularly at the higher rates of irrigation.

Consumptive use of water for the growing season increased with increasing levels of irrigation. At maximum yields, consumptive use varied from 13 to 20 inches and averaged between 15 and 16 inches. This is about 2 inches lower than the consumptive use data for the same crops at Vauxhall and Taber in the same years. Also the consumptive use of water by alfalfa was about 4 inches less at Youngstown than that reported for the Upper Kootenay River Valley in British Columbia*. The water requirements of crops grown at Youngstown were lower than in Southern Alberta or South-Eastern British Columbia, probably because of shorter growing seasons and somewhat lower evaporative power of the atmosphere.

* Krogman, K. K. and L. E. Lutwick. 1961. Consumptive use of water by forage crops in the upper Kootenay River Valley. Can. J. Soil Sci. 41: 1-4.

CONCLUSIONS

1. No treatment was discovered, chemical or physical, which would convert the Hemaruka loam soils to a friable, fertile, irrigation soil.
2. The most promising practical treatments for improving these soils were deep plowing and the application of manure. The practicality of deep plowing would hinge on the economics of the situation.
3. There is practically no internal drainage in these soils and infiltration rates and hydraulic conductivity are too low by present standards for satisfactory irrigation. Applications of small amounts of water would be required too frequently for easy irrigation.
4. Salinity would be a serious hazard if any attempt was made to irrigate these soils.
5. The soils are extremely variable over very short distances resulting in lack of uniformity of crop stands and variations in height, in yield, and in quality.

In brief, the Hemaruka soils of the Wm. Pearce scheme are unsuitable for irrigation in the foreseeable future. The soil survey report indicates that other soils in the irrigable area closely resemble the Hemaruka. The conclusions respecting the Hemaruka soils apply in lesser degree to them. Still other soils, while suitable for irrigation, occur in such small areas and in such intimate association with Hemaruka that they must also be ruled out. When these factors are considered, and in addition topography, availability of water, surface drainage, and salinity, it is evident that larger areas of good irrigable soils in the Wm. Pearce project are few and far between. The time has not yet arrived when we should spend millions of dollars bringing water to these few areas for purposes of irrigation.

A P P E N D I X

Appendix A

Details of the A Plot experiments

Index of contents: Pages

Index of contents:	Pages
Comments concerning the research program	A 2
Plan of the A Plots	A 3
Vegetation prior to plowing	A 4
Photos of A Plots at various stages	A 5, A 6
Annual yields of wheat, 1953-1962	A 7 - A 16
Annual yields of sweet clover, 1954-1962	A 8 - A 16
Comparison of yields on A Plot replicates	A 17
Comparison of yields on A Plot rotations	A 18
Yields averaged as to year, treatment, and rotation	A 19
Comparison of average plot yields with original cover	A 20
Height measurements of barley, 1952	A 21
Height measurements of wheat, 1953	A 22
Height measurements of wheat, 1956	A 23
Protein content of wheat, 1960 and 1961	A 24

Comments Concerning Research Program on A Plots

The plot area was selected and the experimental plots laid out in May, 1952. The area had at one time been cultivated but had been abandoned for many years and had reverted to more or less native cover (see page A 4). After plowing the area was disced, harrowed and the treatments applied.

The objective in this set of plots was to investigate especially the value of certain amendments for improving the irrigability of the soil. It was recognized from the beginning that the soil was extremely variable and a compromise had to be made between number of treatments and number of replications. Coupled with the use of amendments the value of sweet clover as a soil improver needed to be checked. With consideration of all these factors the final design of plots shown on page A 3 was selected with water to be provided by rill irrigation.

The amendments were selected on the basis of previous research in Alberta and elsewhere. Sulphur was known to have an acidifying effect on soils and it was thought its addition might help improve the structure of the Bt horizon. Krilium had just appeared on the market and appeared to offer promise as a soil conditioner. Gypsum had been used for years as a corrective agent in high sodium soils and it was felt this amendment might improve the Hemaruka soils. Farm yard manure was selected as an amendment because of its well-known beneficial effects on the structure of soils, especially those low in organic matter content.

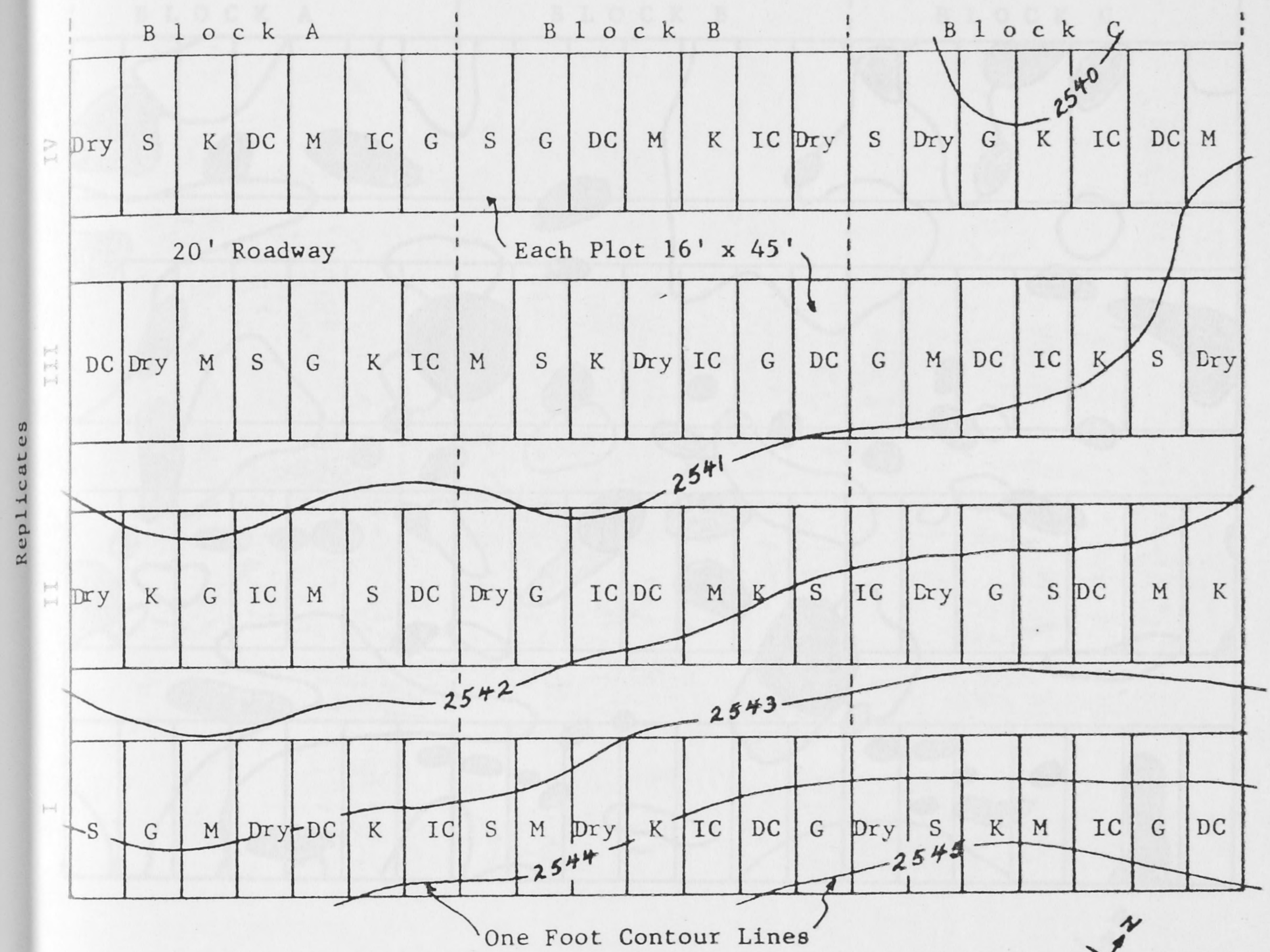
As an additional treatment in the A plots it was felt desirable to test deep tillage. This meant annual chiselling to a depth of about 16 inches at 4-foot intervals in an effort to break up the hardpan and improve infiltration rates and root growth.

To measure the value of these various treatments it was of course necessary to have an irrigated check plot; to measure the value of the irrigation alone, an unirrigated or dry check plot was included. Yields were measured by sampling a strip 3' x 40' down the centre of each plot. From the beginning it was known that data for several years would be required in order to get reliable averages. This became particularly obvious when weather conditions turned out to be unusually favorable for the first few years of the experiments.

Irrigations had to be frequent and rarely exceeded an inch or two of water at a time because of the extremely slow infiltration rates. There was no noticeable improvement in infiltration rates on any of the plots over the ten-year period. From 1957 to 1962 a single sprinkler application was used immediately after seeding to ensure germination.

See pages A 5 and A 6 for photographs of the A plots.

Plan of A Plots



Total Plot Area 336' x 240'

Scale: 1 cm. = 20'

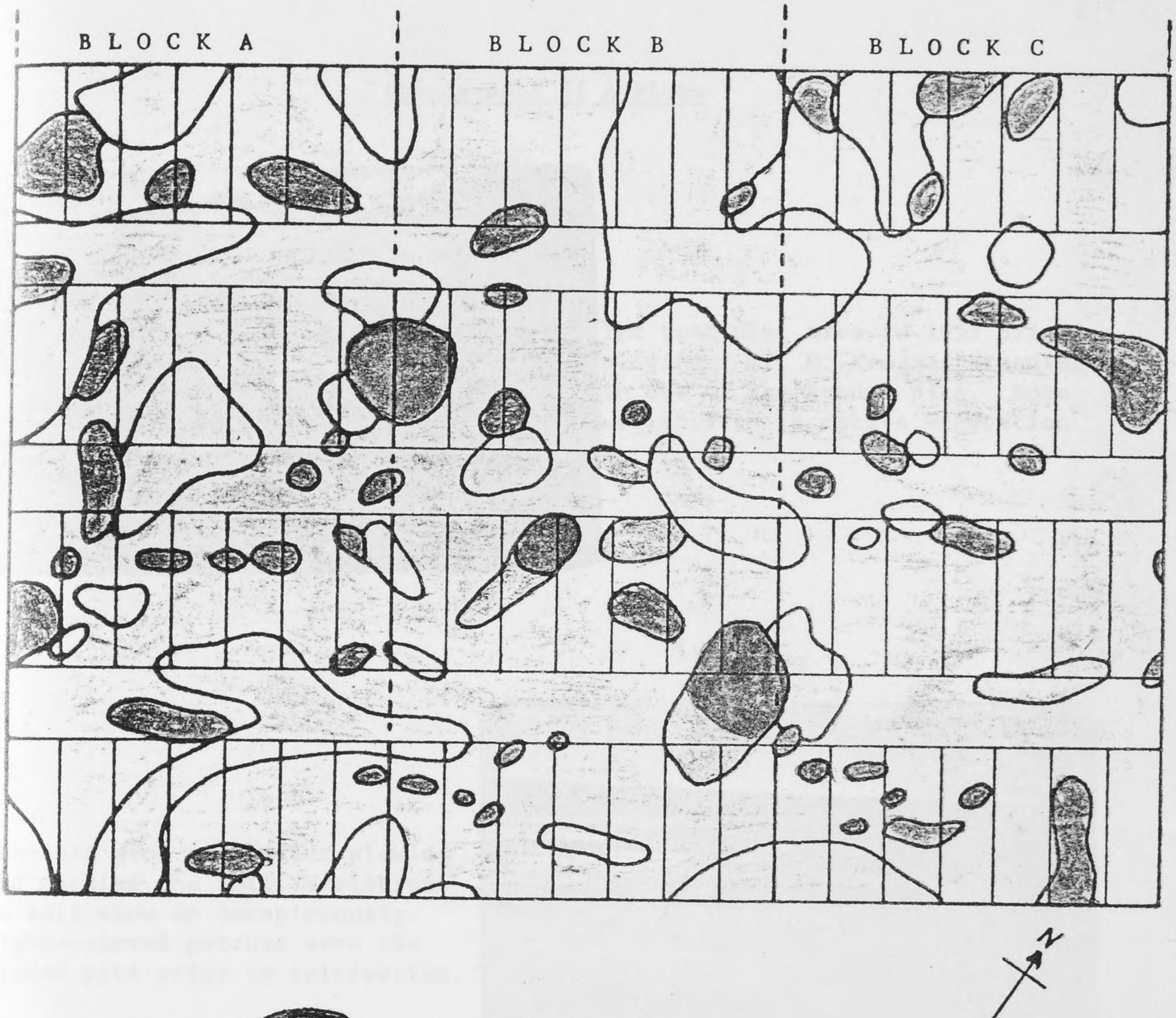
Legend:-

1. Rotations
   Blocks A and C - Alternating sweet clover and wheat. (Sweet clover seeded down with the wheat and plowed under as green manure in July of following year.)
   Block B - Continuous wheat.
2. Amendments

S	-	Sulfur	- 1,000 lb./acre (1952, 1957, 1961)
K	-	Krilium	- 2,000 lb./acre (1952 & 1953)
G	-	Gypsum	- 1,200 lb./acre (1953, 1957, 1961)
M	-	Manure	- 15 T./acre (1952, 1953, 1957, 1961)
DC	-	Deep Cultivation	- 16 - 18" deep (yearly)
IC	-	Irrigated Check	
Dry	-	Dry Check	

Vegetation on A Plots

Prior to Plowing, 1952



Legend:-

Heavy buckbrush

Light buckbrush

Eroded pits

Grass dominant

Sage dominant

Photographs of A Plots

The test plot area in 1952 prior to plowing. Mr. K. Krogman standing in one of the eroded pits. Note variability in native vegetation.

The test plot area after plowing and working the soil. Variations in soil show up conspicuously. Light-colored patches were the eroded pits prior to cultivation.

Replicate III of A Plots being irrigated. Gated pipes were used to apply water to the rills. Ditches on sides of roadway collect spill water.

Photographs of A Plots

Close up of gated pipe and rill irrigation on A Plots. Alternate 6" and 12" drill row spacing can be seen.

Car-top view of the plots showing mainly Replicate III. Blocks A and B in foreground and Block C (Sweet-clover) at far end of the replicates.

The wheat crop on Blocks A and B in 1961. Mr. H. Anderson is standing in the dry check plot with a manured plot just in front of him.

Wheat yield in bu./ac. 1953

Rotations	Treatments	Replicates I	II	III	IV
A	S	29.8	18.6	39.2	28.2
	K	24.8	17.2	26.0	16.7
	G	27.0	20.5	27.6	33.3
	M	33.3	11.7	25.0	26.4
	DC	16.8	17.0	19.8	18.2
	IC	22.9	18.4	24.6	28.2
	Dry	7.1	0.8	7.5	11.4
B	S	27.3	19.6	30.4	36.8
	K	31.0	27.5	28.6	5.5
	G	27.5	33.0	25.8	29.8
	M	15.2	13.4	50.4	47.8
	DC	30.5	20.8	33.7	27.8
	IC	10.4	17.0	16.8	9.8
	Dry	15.3	24.9	29.4	17.4
C	S	28.6	21.0	21.0	36.4
	K	28.6	21.6	26.5	19.7
	G	27.9	36.9	33.6	27.9
	M	31.0	21.0	32.4	37.8
	DC	27.3	27.6	15.2	27.2
	IC	30.4	28.2	19.4	9.3
	Dry	9.8	11.5	10.5	17.1

Sweet clover yields in tons/ac. (Rotation A) and
wheat yields in bu./ac. (Rotations B & C) 1954

Rotations	Treatments	Replicates I	II	III	IV
A	S	2.3	1.1	1.5	2.3
	K	1.5	2.1	0.9	3.1
	G	2.0	1.4	1.7	2.7
	M	1.6	1.7	1.9	1.5
	DC	0.8	2.1	3.7	2.3
	IC	2.1	2.1	1.6	1.5
	Dry	0.9	0.1	1.7	0.9
B	S	17.2	14.7	15.8	16.7
	K	23.9	23.7	23.3	18.8
	G	20.2	18.9	18.1	11.1
	M	16.0	23.0	31.5	25.9
	DC	22.3	21.5	11.2	20.1
	IC	20.2	19.7	9.8	20.2
	Dry	9.1	19.3	16.0	11.1
C	S	16.3	17.4	13.9	13.9
	K	19.6	19.7	15.4	18.1
	G	16.8	21.9	21.1	18.6
	M	23.7	29.2	26.5	27.4
	DC	20.0	21.5	12.3	21.8
	IC	18.6	18.1	10.7	11.8
	Dry	8.4	6.7	0.1	8.8

Wheat yields in bu./ac. (Rotations A & B) and sweet clover yields in tons/ac. (Rotation C) in 1955

Rotations	Treatments	Replicates I	II	III	IV
A	S	42.2	29.9	39.5	40.1
	K	23.9	44.2	29.3	39.8
	G	38.3	34.5	31.0	36.5
	M	40.8	18.8	40.6	32.5
	DC	12.4	30.7	55.0	37.3
	IC	25.0	33.8	35.8	15.8
	Dry	8.4	4.8	13.2	0.9
B	S	25.8	13.6	26.2	27.9
	K	17.6	23.4	27.0	27.9
	G	17.3	20.5	17.8	18.4
	M	29.5	20.8	45.5	20.2
	DC	24.4	17.3	25.3	21.3
	IC	22.6	22.7	19.1	21.2
	Dry	14.2	24.5	21.1	9.8
C	S	1.2	0.2	0.5	0.5
	K	2.3	1.4	0.4	0.5
	G	1.1	1.2	0.8	0.6
	M	1.1	0.5	1.2	0.8
	DC	0.8	0.9	1.3	0.7
	IC	2.3	0.5	0.4	0.4
	Dry	0.6	0.3	0.1	0.8

Sweet clover yields in tons/ac. (Rotation A) and

wheat yields in bu./ac. (Rotations B & C) 1956

Rotations	Treatments	Replicates I	II	III	IV
A	S	2.0	1.1	1.2	1.4
	K	1.2	1.4	.2	1.5
	G	1.5	1.2	1.2	1.9
	M	1.9	1.2	.8	.7
	DC	.6	1.0	1.8	1.3
	IC	.9	1.0	.6	.8
	Dry	.3	0	.6	0
B	S	22.7	16.7	20.1	35.6
	K	25.1	24.0	24.9	16.8
	G	29.2	24.1	22.2	19.9
	M	25.3	20.2	38.4	44.0
	DC	24.2	16.1	27.3	20.3
	IC	22.5	20.1	15.6	23.5
	Dry	22.0	22.8	19.0	11.9
C	S	45.8	31.3	24.1	36.0
	K	50.5	40.1	20.0	19.4
	G	39.2	33.7	31.9	21.4
	M	39.8	43.6	35.6	48.5
	DC	31.0	32.0	28.4	33.4
	IC	41.6	30.9	18.2	12.5
	Dry	19.6	18.5	8.8	12.0

Wheat yields in bu./ac. (Rotations A & B) and

sweet clover yields in tons/ac. (Rotation C) in 1957*

Rotations	Treatments	Replicates I	II	III	IV
A	S	36	25	22	37
	K	8	30	25	37
	G	47	29	21	44
	M	27	34	24	32
	DC	20	29	29	24
	IC	24	32	27	20
	Dry	0	0	0	0
B	S	19	15	36	22
	K	14	22	38	27
	G	29	36	21	16
	M	27	28	37	42
	DC	24	45	26	33
	IC	13	29	21	30
	Dry	0	3	9	0
C	S	1.9	.1	.3	.6
	K	2.4	1.1	.2	.4
	G	.6	.9	.4	.3
	M	1.6	.7	.8	.9
	DC	.8	.8	.7	1.0
	IC	2.0	.3	.1	.1
	Dry	.3	.2	.3	.4

* Adjusted for hail damage

Sweet clover yields in tons/ac. (Rotation A) and

wheat yields in bu./ac. (Rotations B & C) 1958

Rotations	Treatments	Replicates I	II	III	IV
A	S	2.2	0.9	0.3	3.7
	K	0.7	1.4	1.6	2.8
	G	1.4	1.5	2.5	1.9
	M	0.7	1.3	1.5	1.5
	DC	0.7	0.9	2.4	2.9
	IC	0.5	0.8	0.9	1.1
	Dry	0.2	0.0	0.5	0.0
B	S	27.1	21.6	24.0	26.4
	K	16.9	22.6	27.0	67.3
	G	18.6	20.4	28.1	19.2
	M	29.6	28.7	40.8	40.8
	DC	29.0	31.2	31.0	19.7
	IC	14.5	27.1	28.1	31.8
	Dry	7.1	6.6	40.1	8.2
C	S	44.4	27.5	30.5	31.1
	K	55.5	34.6	21.8	31.1
	G	35.2	36.1	36.7	41.1
	M	47.9	55.4	50.2	26.3
	DC	33.3	35.3	39.4	28.6
	IC	46.1	26.8	21.6	15.2
	Dry	4.5	11.2	17.2	6.4

Wheat yields in bu./ac. (Rotations A & B) and

sweet clover yields in tons/ac. (Rotation C) in 1959

Rotations	Treatments	Replicates I	II	III	IV
A	S	19.5	23.0	31.6	34.7
	K	17.5	23.9	40.0	37.7
	G	18.6	20.4	28.8	22.2
	M	25.7	22.2	31.8	30.4
	DC	26.6	31.9	40.0	35.3
	IC	15.5	24.7	33.7	24.6
	Dry	2.5	2.7	6.7	6.0
B	S	19.2	14.2	22.7	22.2
	K	18.5	17.6	30.0	24.7
	G	14.0	23.4	22.8	18.4
	M	25.0	20.5	30.0	32.7
	DC	25.9	29.2	20.0	24.8
	IC	16.8	22.0	19.4	27.0
	Dry	4.2	3.3	9.5	6.4
C	S	1.0	0.2	1.4	1.6
	K	1.0	0.9	0.5	0.7
	G	0.9	0.3	0.7	0.6
	M	1.0	1.1	1.2	1.3
	DC	1.2	0.5	0.6	0.6
	IC	2.2	0.5	0.4	0.3
	Dry	0.0	0.0	0.0	0.5

Sweet clover yields in tons/ac. (Rotation A) and wheat yields in bu./ac. (Rotations B & C) 1960

Rotations	Treatments	Replicates I	II	III	IV
A	S	1.0	0.9	0.1	0.2
	K	0.5	0.6	0.2	0.3
	G	0.9	0.7	0.3	0.4
	M	0.8	1.9	0.7	1.2
	DC	1.3	1.7	0.4	0.2
	IC	0.6	0.9	0.3	0.5
	Dry	0.0	0.0	0.2	0.2
B	S	15.8	18.9	21.6	18.5
	K	17.3	25.2	24.5	22.2
	G	25.7	21.8	23.1	20.9
	M	39.1	41.8	26.9	29.6
	DC	26.4	22.6	30.0	21.9
	IC	17.3	22.5	22.9	25.5
	Dry	5.3	10.4	27.0	9.4
C	S	40.4	19.3	32.1	32.4
	K	40.6	27.0	25.8	33.7
	G	34.5	24.2	27.2	40.3
	M	22.5	43.5	42.4	42.9
	DC	10.7	22.8	45.7	7.8
	IC	41.3	21.4	16.8	12.1
	Dry	1.2	2.9	1.1	12.7

Wheat yields in bu./ac. (Rotations A & B) and

sweet clover yields in tons/ac. (Rotation C) in 1961

Rotations	Treatments	Replicates I	II	III	IV
A	S	14.8	23.8	28.0	28.5
	K	14.3	28.2	25.5	24.8
	G	26.9	29.0	33.7	29.1
	M	40.6	34.6	34.7	32.7
	DC	21.5	21.7	31.0	29.1
	IC	15.0	24.7	32.1	30.8
	Dry	2.1	9.6	11.6	4.2
B	S	16.4	5.8	17.2	15.6
	K	7.8	11.0	12.8	12.7
	G	5.2	20.3	13.6	13.0
	M	22.9	16.0	20.9	15.5
	DC	12.0	11.4	14.3	13.1
	IC	9.6	13.9	9.6	8.1
	Dry	0.2	0.2	8.1	0.2
C	S	1.0	0.5	1.4	1.4
	K	1.0	0.5	1.2	0.9
	G	1.1	0.5	0.8	0.8
	M	0.9	0.5	0.5	0.5
	DC	0.4	0.4	0.5	0.4
	IC	0.6	0.6	0.6	0.6
	Dry	0.0	0.0	0.1	0.5

Sweet clover yields in tons/ac. (Rotation A) and

wheat yields in bu./ac. (Rotations B & C) 1962

Rotations	Treatments	Replicates I	II	III	IV
A	S	1.1	0.8	0.6	0.6
	K	0.5	1.1	0.5	1.4
	G	0.7	0.9	0.5	2.1
	M	1.6	1.8	1.8	1.1
	DC	0.5	1.1	1.3	1.3
	IC	0.3	0.6	0.7	1.1
	Dry	0.0	0.0	0.7	0.0
B	S	13.8	13.4	14.2	15.5
	K	21.0	18.9	15.1	13.7
	G	20.0	15.6	21.0	15.2
	M	22.3	19.2	14.3	13.8
	DC	23.5	20.5	18.8	14.3
	IC	16.6	20.7	18.5	15.4
	Dry*	2.5	2.5	2.5	2.5
C	S	30.7	23.3	28.0	19.7
	K	23.2	19.4	19.5	23.5
	G	28.7	31.9	22.2	17.8
	M	32.8	16.3	21.1	17.7
	DC	21.3	21.2	27.0	15.4
	IC	29.4	14.8	18.2	15.2
	Dry*	2.5	2.5	2.5	2.5

* Plots not sampled. Average yield estimated visually.

Comparison of yields on A plot replicates

wheat (bu./ac.)

	Replicates							
	I		II		III		IV	
Blocks Year	AB	BC	AB	BC	AB	BC	AB	BC
1953	22.6	24.2	18.5	23.0	27.3	25.8	23.7	24.4
1954		18.0		19.7		16.1		17.4
1955	24.5		24.2		30.5		25.4	
1956		31.3		26.7		23.9		25.4
1957*	20.6		25.5		24.0		26.0	
1958		29.3		27.5		31.2		28.1
1959	17.8		19.9		26.2		24.8	
1960		24.2		23.2		26.2		23.6
1961	15.2		17.2		20.9		18.4	
1962		20.6		17.2		17.4		14.4
1953-62 Ave.	20.1	24.6	21.1	22.9	25.8	23.4	23.7	22.2
	22.3		22.0		24.6		22.9	

* Yields were adjusted in accordance with visual estimates of damage resulting from a hail storm.

Comparison of yields on A plot rotations

wheat (bu./ac.)

	BLOCK		
Year	A	B	C
1953	21.9	24.9	24.0
1954		18.5	17.1
1955	30.0	22.2	
1956		23.4	30.3
1957	24.4	23.6	
1958		26.2	31.8
1959	24.2	20.2	
1960		22.6	26.0
1961	24.5	11.7	
1962		14.9	19.3
1953-62 Ave.	25.0	20.8	24.7

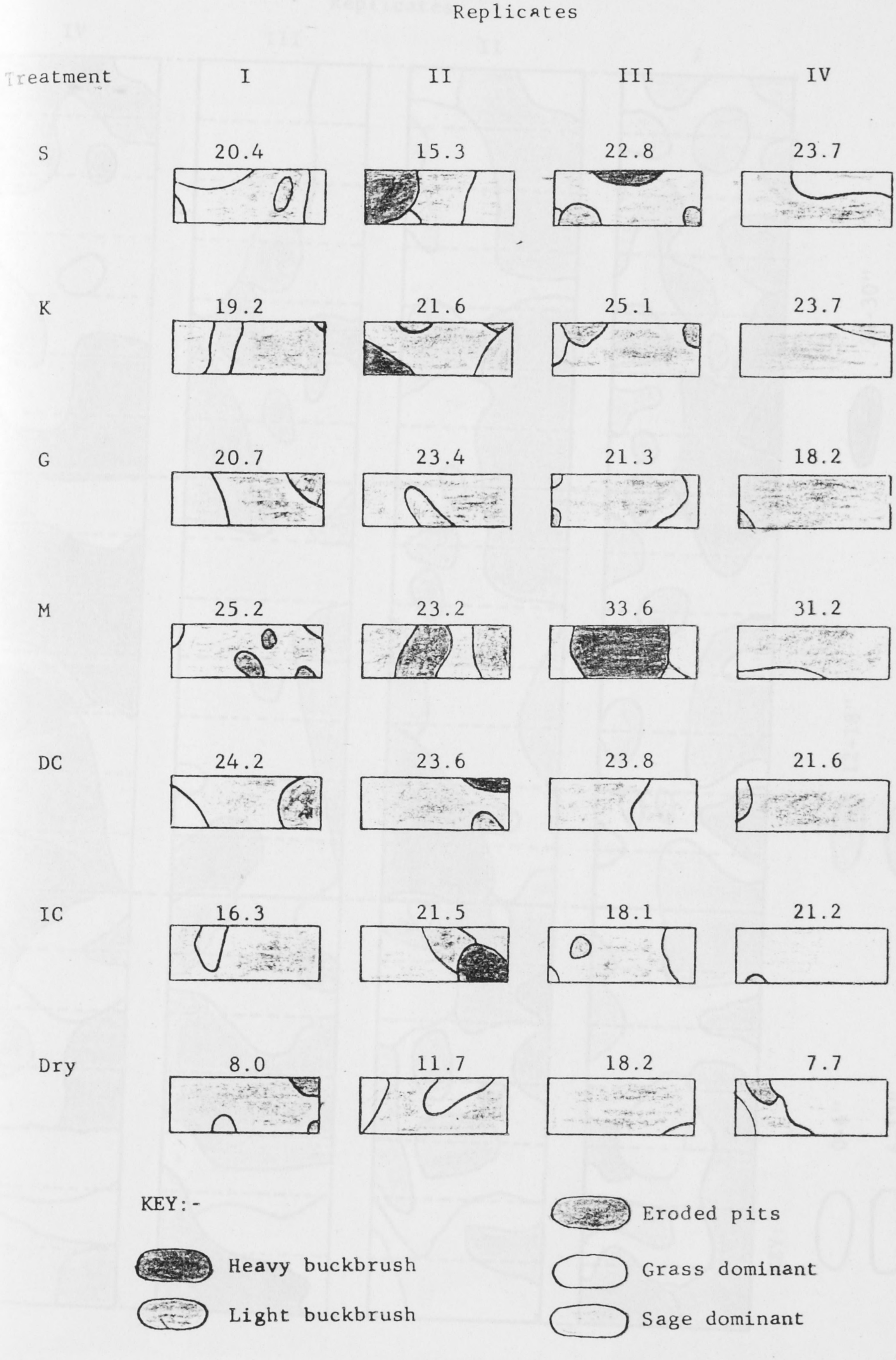
Ave. of Blocks A & C (Wheat, sweet clover rotation)	24.9
Ave. of Block B (Continuous wheat)	20.8
Difference attributed to rotation	4.1

Yields on A plots averaged as to year, treatment, and rotation

Year	Sulphur			Krilium			Gypsum			Manure			Deep Cultivation			Irrigated Check			Dry Check		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1953	29.3	28.9	27.1	21.5	23.5	24.4	27.4	29.4	32.0	24.4	32.2	30.9	18.2	28.6	24.6	23.8	12.7	22.1	6.8	22.0	9.7
1954	1.8*	16.1	15.4	1.9*	22.4	18.2	1.9*	17.1	19.6	1.7*	24.4	26.7	2.2*	18.8	18.9	1.8*	17.5	14.8	0.9*	13.9	6.0
1955	37.9	23.4	0.6*	34.3	24.0	1.3*	35.1	18.5	0.9*	33.2	29.0	0.9*	33.9	22.1	0.9*	27.6	21.4	0.9*	8.4	17.4	0.5*
1956	1.4*	23.8	34.3	1.1*	22.7	32.4	1.4*	23.8	31.6	1.2*	32.0	41.9	1.2*	22.0	31.2	0.8*	20.4	25.8	0.2*	18.9	14.7
1957	30.0	23.0	0.7*	25.0	25.2	1.0*	35.2	25.4	0.6*	29.2	33.5	1.0*	25.4	32.0	0.8*	25.7	23.2	0.7*	0.0	3.0	0.3*
1958	1.8*	24.8	33.4	1.6*	33.5	35.8	1.8*	21.6	37.3	1.2*	35.0	45.0	1.7*	27.7	34.2	0.8*	25.4	27.4	0.2*	15.5	9.8
1959	27.2	19.5	1.0*	29.7	22.7	0.8*	22.5	19.6	0.6*	27.5	27.0	1.1*	33.4	24.9	0.7*	24.6	21.3	0.8*	4.4	5.8	0.1*
1960	0.5*	18.7	31.1	0.4*	22.3	31.8	0.6*	22.9	31.5	1.1*	34.3	37.8	0.9*	25.2	21.7	0.6*	22.1	22.9	0.1*	13.0	4.5
1961	24.8	13.8	1.1*	23.2	11.1	0.9*	29.7	13.0	0.8*	35.7	18.8	0.6*	25.6	12.7	0.5*	25.7	10.3	0.6*	6.8	2.2	0.2*
1962	0.8*	14.2	25.4	0.9*	17.2	21.4	1.1*	18.0	25.2	1.6*	17.4	22.0	1.1*	19.3	21.2	0.7*	17.8	19.4	0.2*	2.5	2.5
Averages	29.8	20.6	27.8	26.7	22.5	27.3	30.0	20.9	29.5	30.0	27.7	34.0	27.3	23.3	25.3	25.5	19.2	22.1	5.3	11.4	7.9
Ave. of A&C: Wheat		28.8			27.0			29.7			32.0			26.3			23.8			6.6	
Sw. Cl.		1.1			1.1			1.1			1.2			1.1			0.8			0.3	

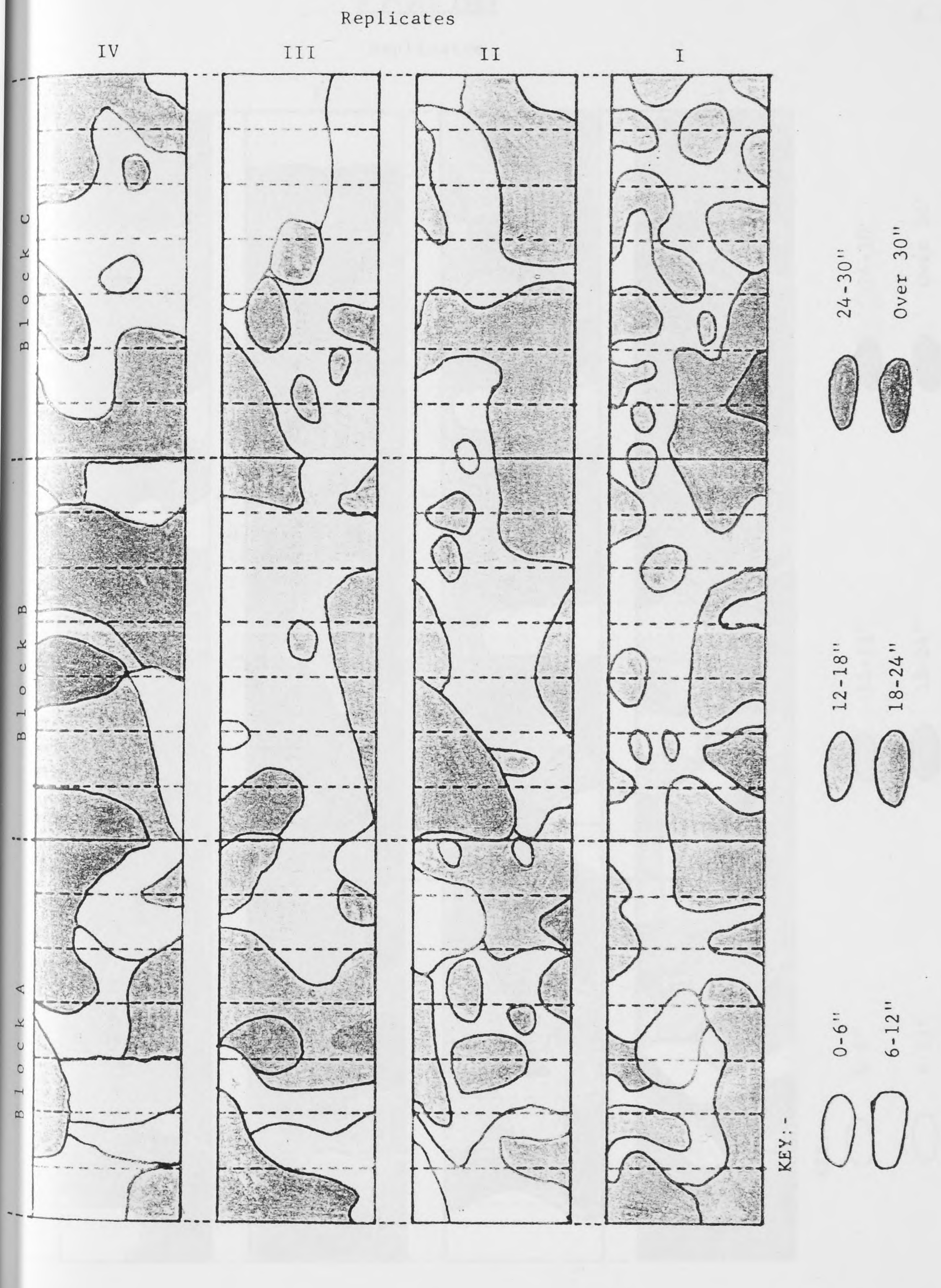
* Sweet clover yields. Other figures refer to yields of wheat. Each figure in main body of the table is the average of four replicates.

Comparison of Individual Plots, Rot. B with respect to wheat yields, 1953-62, and original cover



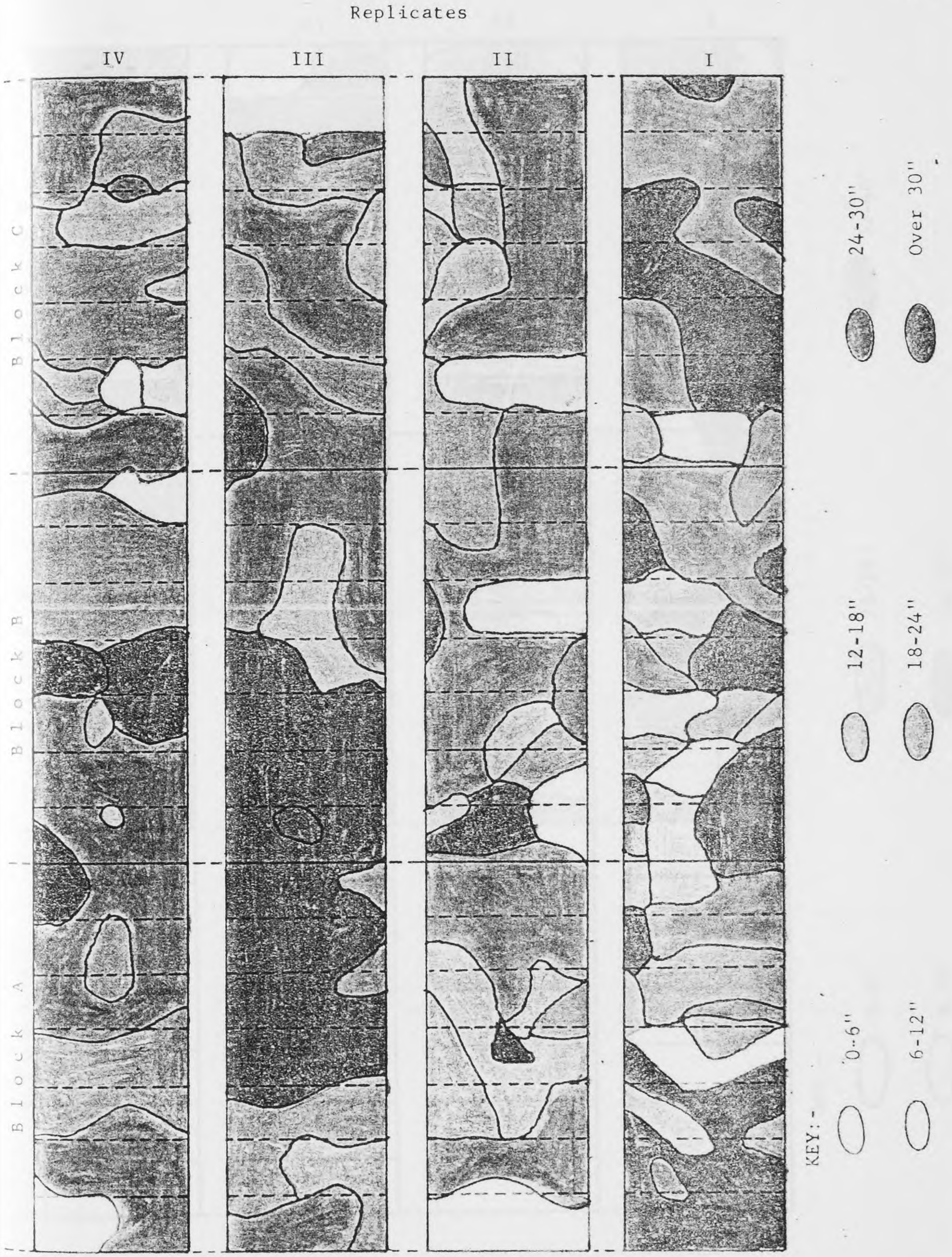
Height Measurements of Barley

A Plots - 1952



Height Measurements of Wheat

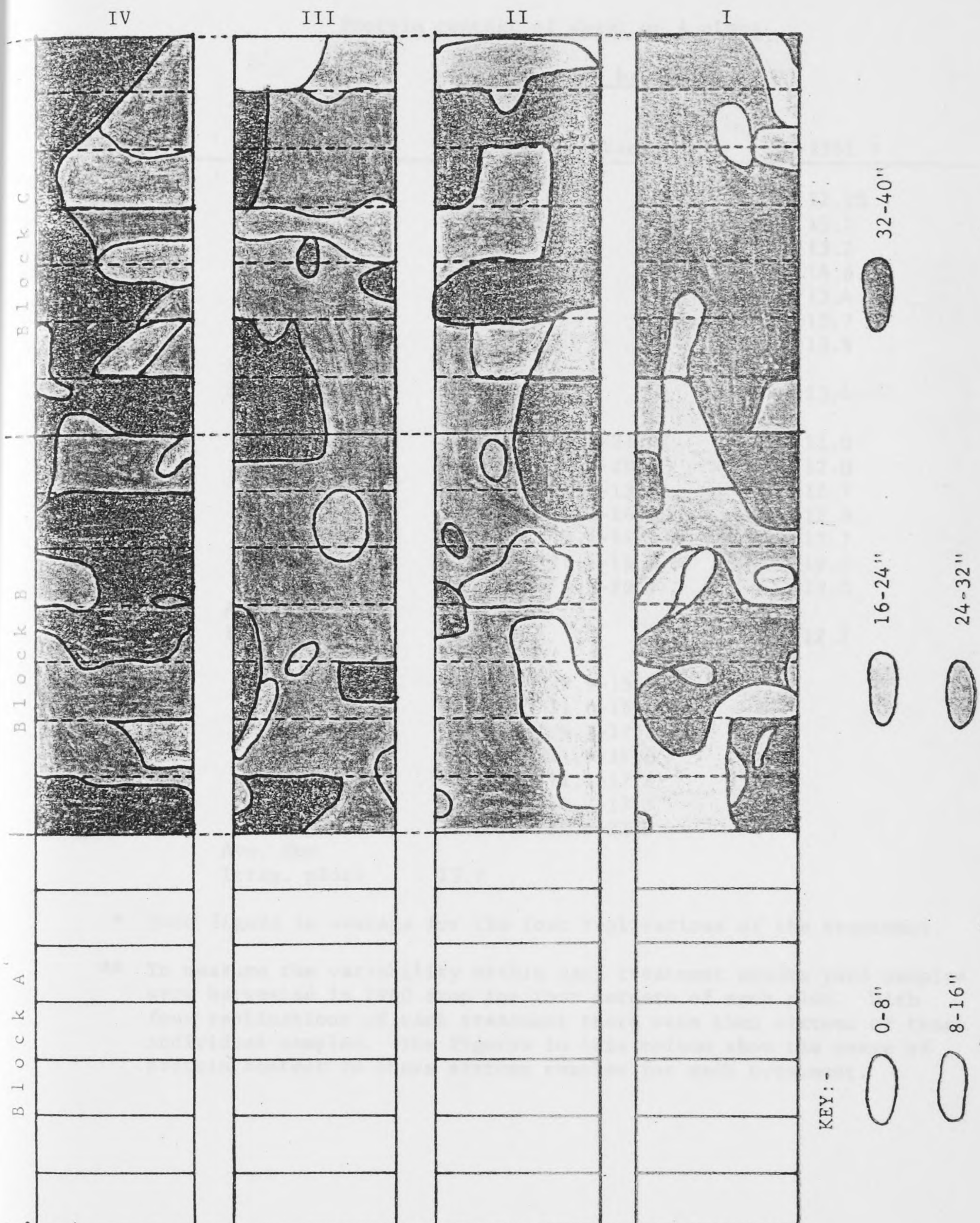
A Plots 1953



Height Measurements of Wheat

A Plots 1956

Replicates



Protein content of wheat on A plots

(14% moisture basis)

Block	Treatment	1960 *	Range * *	1961 *
A	S	-		12.3%
	K			13.2
	G			13.2
	M			14.6
	DC			13.4
	IC			13.7
	Dry			13.5
	Ave. for Irrig. plots			13.4
B	S	14.4%	9.4-21.4%	11.0
	K	12.1	10.1-20.5	12.0
	G	11.2	10.1-13.8	12.7
	M	12.5	10.3-16.0	12.8
	DC	10.7	9.6-14.3	12.7
	IC	11.3	10.4-16.2	12.0
	Dry	16.3	9.8-20.9	13.0
	Ave. for Irrig. plots	12.0		12.2
C	S	12.9	9.9-15.5	
	K	12.6	11.6-15.7	
	G	13.6	9.7-17.8	
	M	14.4	11.6-19.0	
	DC	14.5	11.1-17.8	
	IC	14.2	10.7-17.2	
	Dry	17.6	12.5-22.3	
	Ave. for Irrig. plots	13.7		

* Each figure is average for the four replications of the treatment.

** To measure the variability within each treatment square yard samples were harvested in 1960 from the four corners of each plot. With four replications of each treatment there were then sixteen of these individual samples. The figures in this column show the range of protein content in these sixteen samples for each treatment.

Appendix B

Details of the B Plot experiments

Index of contents: Pages

Comments concerning the research program	B 2
Plan of the B Plots	B 3
Photos of B Plots	B 4, B 5
Height of blanket crop of barley 1953	B 6
Annual yields 1954-1962	B 7-B 15
Average yields, irrigated plots	B 16
Average yields, dry plots	B 17
Height of wheat and oats, 1956	B 18
Average yields, wheat after alfalfa	B 19

Comments Concerning Research Program on B Plots

To supplement the information provided from the A plots a second area was selected for a more detailed study of cultural management of the Hemaruka soils. The area selected was one on virgin prairie.

The main objectives in the setting up of the B plots were:

(1) To test the value of different tillage methods, namely deep cultivation or ripping to 20" depth at 4-foot intervals, plowing to a depth of 18", chiselling to 8" depth, and normal shallow cultivation.

(2) To test the value of crop rotation and deep-rooted legumes, alfalfa and sweet clover, as agents for opening up the soil and improving irrigability.

(3) To evaluate the adaptability of the sprinkler method of irrigation.

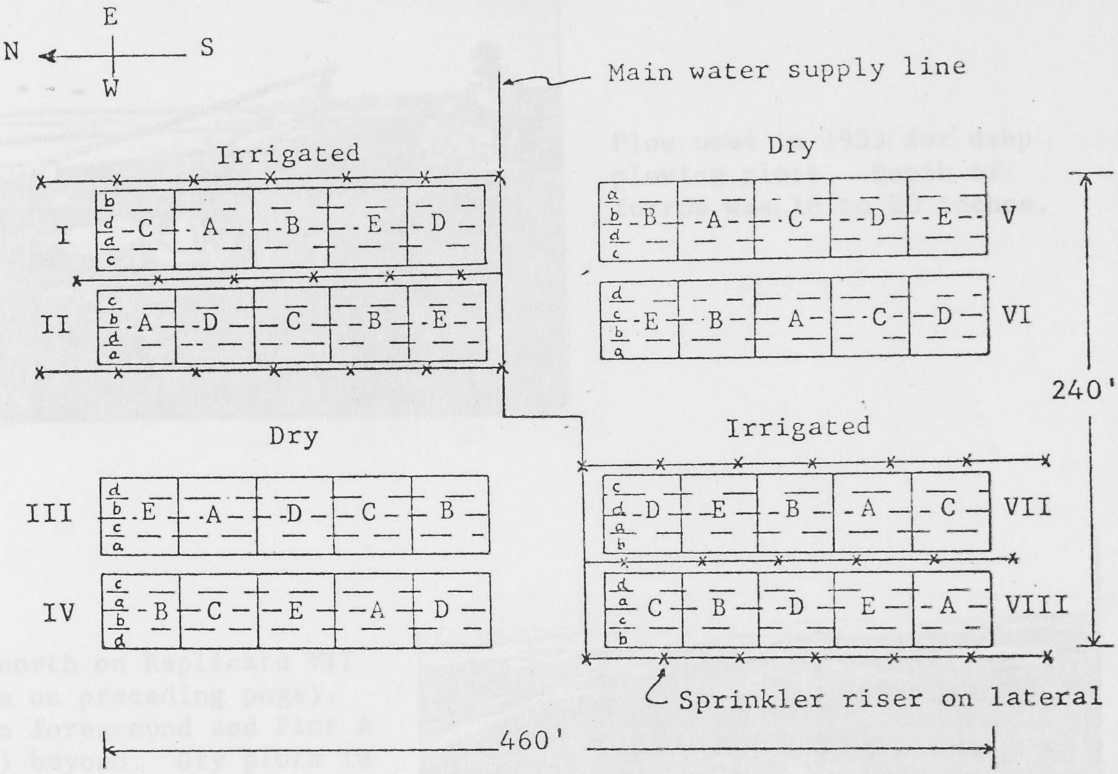
A plan of the plots is given on page B 3. First the whole area was plowed and worked up. A blanket crop of barley was seeded in June, 1953, to serve as an indicator of the uniformity of the whole area. As expected, of course, there was extreme variation. See page B 6. Deep plowing and ripping were done in the fall of 1953 and the plots laid out in the spring of 1954. Each individual plot area measured 10 x 40 feet. Different crops and rotations were used as indicated on page B 3. Recommended rates of fertilization were used each year.

Photographs on pages B 4 and B 5 illustrate various features of the B plots and pages B 7 to B 19 present data on yields.

In August of 1956 and 1961 the alfalfa plots (Treatment A) were plowed up and worked down preparatory to seeding to wheat the following years. See page B 19.

Plan of B plots

Scale: 1 cm. = 40 ft.



TREATMENTS

A. Alfalfa - in irrigated plots left for 5 years. Sweet clover or Grass - in dry plots.

B. Deep cultivation or Ripping, 20" deep, 1st year, then normal cultivation.

C. Deep plowing, 18" deep, 1st year, then normal cultivation.

D. Shallow-deep cultivation, using farm machinery and farm tractor power.

E. Check. Normal shallow cultivation.

CROP ROTATION

Irrigated

1. a - Wheat

   b - Oats + Sw. cl.

   c - Sw. clover

2. d - Continuous wheat

Dry

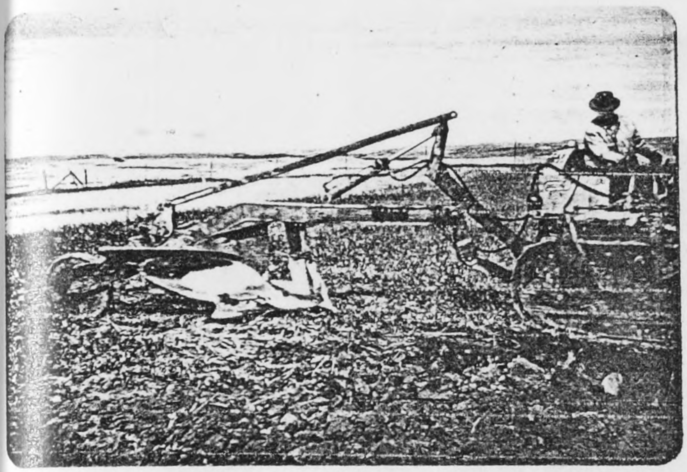
1. a - Wheat

   b - Oats + Sw. cl.

   c - Sw. clover

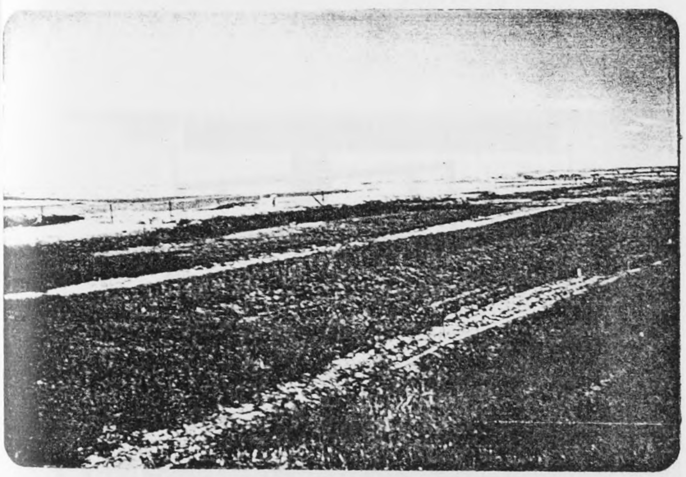
2. d - Wheat-fallow

Photographs of B Plots



Plow used in 1953 for deep plowing plots. Depth of furrow was 18 to 20 inches.

Looking north on Replicate VII (See plan on preceding page). Plot C in foreground and Plot A (alfalfa) beyond. Dry plots in the distance. Note variable alfalfa stand.

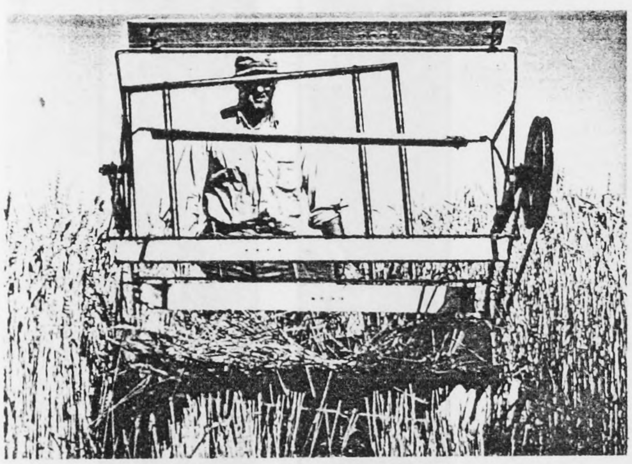


Replicates I and II and the dam in the background. Alfalfa (Treatment A) on Rep. II at bottom left and on Rep. I at left centre. Sprinkler line and roadway bottom right.

Photographs of B Plots

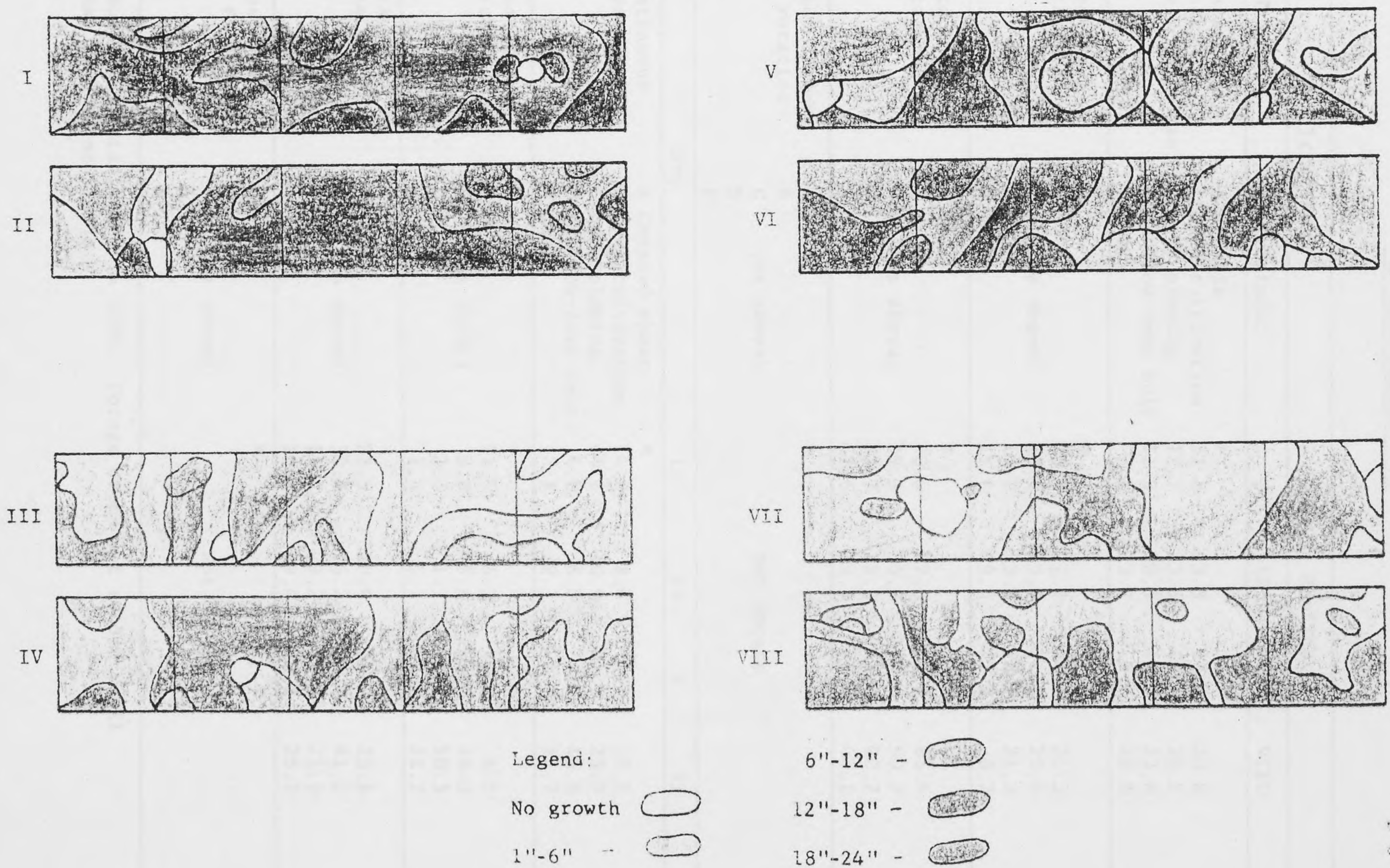
Irrigated alfalfa plot in Rep. II showing extreme variation in stand as a result of soil variability. Yield varying from 0.5 to 2.5 tons per acre.

Fairly good stands of irrigated wheat and oats on deep plowing plot, Rep. II, and on deep cultivation plot, Rep. I in background.



Special machine designed by A. L. Mathieu used for sampling wheat and oats on Youngstown plots. Being operated here by G. Tajcnar.

Uniformity of B plots as shown by height
of barley crop prior to treatments, September 1953
(All plots unirrigated)



"B" Plot Yields 1954

Irrigated		Replicates			
Rotation	Treatment	I	II	VII	VIII
d - Continuous wheat Yield in bu./ac.	A Alfalfa	*			
	B Deep cultivation	22.8	23.3	16.4	23.8
	C Deep plowing	12.7	23.5	19.4	29.2
	D Shallow-deep cult.	11.3	10.5	10.7	23.8
	E Check	7.1	13.7	9.6	15.8
a - Wheat in rotation	A	*			
	B	23.7	27.2	20.0	21.3
	C (as above)	20.1	25.0	21.1	25.4
	D	11.1	13.9	18.4	21.3
	E	11.6	19.6	11.7	8.3
b - Oats in rotation	A	*			
	B	68.4	67.6	59.6	65.4
	C (as above)	29.9	56.8	65.4	50.7
	D	33.7	35.3	53.4	42.7
	E	42.6	29.5	48.9	42.1
c - Sweet clover in rotation	A	*			
	B				
	C (as above)		Not Mature		
	D				
	E				
Dry		III	IV	V	VI
d - Continuous wheat	A Crested wheat	*			
	B Deep cultivation	14.8	8.6	14.9	17.1
	C Deep plowing	14.9	10.9	24.8	25.5
	D Shallow-deep cult.	4.0	6.5	4.7	15.6
	E Check	2.5	2.1	0.8	12.7
a - Wheat in rotation	A	*			
	B	11.5	6.3	20.8	4.5
	C (as above)	9.0	5.6	23.0	18.3
	D	2.6	1.1	7.3	10.5
	E	1.8	5.1	2.3	12.2
b - Oats in rotation	A	*			
	B	23.5	20.9	31.7	23.6
	C (as above)	30.8	26.2	37.2	41.2
	D	15.2	29.2	14.7	21.8
	E	16.7	19.4	18.1	25.1
c - Sweet clover in rotation	A	*			
	B				
	C (as above)		Not Mature		
	D				
	E				

* Rotations established in 1954. Forage crops not seeded until May 1954 so no yields.

"B" Plot Yields 1955

Irrigated		Replicates			
Rotation	Treatment	I	II	VII	VIII
d - Continuous wheat Yield in bu./ac.	A Alfalfa	3.25*	2.0	2.5	2.5
	B Deep cultivation	22.4	35.5	20.7	26.7
	C Deep plowing	35.6	49.8	24.9	35.3
	D Shallow-deep cult.	11.2	26.7	18.8	15.7
	E Check	17.0	22.1	19.1	22.8
a - Wheat in rotation	A	1.25*	1.25	3.0	1.1
	B	39.2	31.3	42.2	25.6
	C (as above)	28.9	24.2	22.1	32.5
	D	15.9	35.4	40.8	34.6
	E	32.7	20.1	33.4	27.0
b - Oats in rotation	A	1.25*	1.25	3.0	2.6
	B	13.8	69.8	45.1	86.7
	C (as above)	40.3	112.2	44.7	53.2
	D	34.2	49.0	14.6	61.0
	E	31.7	36.6	40.2	27.4
c - Sweet clover in rotation	A	1.25*	1.5	1.75	3.5
	B	2.0	2.6	2.0	2.0
	C (as above)	1.9	2.4	2.7	2.0
	D	1.5	0.2	1.8	0.8
	E	1.5	1.3	0.9	2.0
Dry		III	IV	V	VI
d - Continuous wheat	A Crested wheat	Insufficient growth for sampling.			
	B Deep cultivation				
	C Deep plowing				
	D Shallow-deep cult.	Fallowed			
	E Check				
a - Wheat in rotation	A	(see above)			
	B	17.0	18.8	26.0	9.3
	C (as above)	9.6	13.4	19.9	19.5
	D	17.5	11.7	13.6	12.1
	E	17.7	15.1	2.6	12.0
b - Oats in rotation	A	(see above)			
	B	15.7	20.6	58.8	16.5
	C (as above)	26.5	37.6	16.9	52.8
	D	50.0	1.8	32.3	50.4
	E	7.8	28.5	32.0	57.9
c - Sweet clover in rotation	A	(see above)			
	B	2.2*	1.2	1.8	0.7
	C (as above)	1.6	1.1	1.4	2.3
	D	1.8	1.6	1.0	1.8
	E	1.0	0.4	1.1	2.0

* Alfalfa and sweet clover yields in tons per acre.

"B" Plot Yields 1956

Irrigated		Replicates			
Rotation	Treatment	I	II	VII	VIII
d - Continuous wheat Yield in bu./ac.	A Alfalfa	Severe winterkilling. No yield data.			
	B Deep cultivation	24.7	27.6	29.3	43.1
	C Deep plowing	36.1	36.2	23.0	34.2
	D Shallow-deep cult.	14.2	15.7	25.6	19.9
	E Check	16.1	31.2	21.1	28.1
a - Wheat in rotation	A	(see above)			
	B	41.3	44.0	45.4	45.6
	C (as above)	50.7	47.3	45.2	53.3
	D	28.0	30.2	41.1	43.6
	E	27.3	33.3	40.4	41.2
b - Oats in rotation	A	(see above)			
	B	89.3	96.5	86.8	96.8
	C (as above)	42.1	97.9	96.3	108.8
	D	20.5	71.5	103.5	97.9
	E	83.5	46.7	95.1	88.1
c - Sweet clover in rotation	A	(see above)			
	B	1.8	1.5	0.6	0.8
	C (as above)	0.9	1.5	1.3	0.6
	D	0.9	0.6	0.2	0.9
	E	0.8	1.2	0.2	0.2
Dry		III	IV	V	VI
d - Continuous wheat	A Crested wheat*	0.58	0.75	0.53	0.49
	B Deep cultivation	24.9	35.7	41.3	31.5
	C Deep plowing	32.3	26.4	50.6	29.7
	D Shallow-deep cult.	46.7	30.9	36.7	47.8
	E Check	16.7	19.7	15.8	31.8
a - Wheat in rotation	A	0.58	0.75	0.53	0.49
	B	27.5	25.9	47.7	8.9
	C (as above)	13.4	25.4	42.8	34.2
	D	39.7	38.7	19.1	48.1
	E	12.5	25.5	18.9	30.4
b - Oats in rotation	A	0.58	0.75	0.53	0.49
	B	22.0	71.1	90.0	67.8
	C (as above)	28.2	79.9	72.8	38.8
	D	83.9	55.6	67.6	64.6
	E	91.9	62.6	25.6	62.4
c - Sweet clover in rotation	A	0.58	0.75	0.53	0.49
	B				
	C (as above)	Sweet clover yield on dry plots nil.			
	D				
	E				

* Crested wheat yields in tons per acre.

"B" Plot Yields 1957

(After adjustments for hail damage)

Irrigated		Replicates			
Rotation	Treatment	I	II	VII	VIII
d - Continuous wheat Yield in bu./ac.	A Alfalfa*	15.0	15.0	5.0	16.0
	B Deep cultivation	26.0	20.0	7.0	15.0
	C Deep plowing	9.0	13.0	9.0	15.0
	D Shallow-deep cult.	29.0	26.0	7.0	19.0
	E Check	5.0	30.0	18.0	11.0
a - Wheat in rotation	A*	18.0	44.0	8.0	28.0
	B	47.0	47.0	14.0	16.0
	C (as above)	29.0	38.0	14.0	27.0
	D	47.0	51.0	39.0	28.0
	E	13.0	23.0	24.0	10.0
b - Oats in rotation	A				
	B				
	C (as above)	Oats hailed out.			
	D				
	E				
c - Sweet clover in rotation	A*	-	-	-	-
	B	1.0	1.5	0.4	0.6
	C (as above)	0.7	1.0	0.1	0.4
	D	0.3	1.0	0.9	0.5
	E	1.4	0.3	0.5	0.6

* Alfalfa plowed in July, 1956 and seeded to wheat in 1957.

Dry		III	IV	V	VI
d - Continuous wheat	A Crested wheat**				
	B Deep cultivation				
	C Deep plowing	Summerfallowed			
	D Shallow-deep cult.				
	E Check				
a - Wheat in rotation	A	6.3	1.7	0	0
	B	0	0	0	0
	C (as above)	0	0	0	0
	D	1.4	1.5	0	0
	E	1.7	1.9	0	0
b - Oats in rotation	A				
	B				
	C (as above)	Oats hailed out.			
	D				
	E				
c - Sweet clover in rotation	A	-	-	-	-
	B	0.3	0.1	0.4	0.3
	C (as above)	0.7	0.3	0.1	0.3
	D	0.4	0.3	0.3	0.4
	E	0.1	0.9	0.3	0.1

** Crested Wheat plowed in fall 1956. Grain seeded in 1957.

"B" Plot Yields 1958

Irrigated		Replicates			
Rotation	Treatment	I	II	VII	VIII
d - Continuous wheat Yield in bu./ac.	A Alfalfa*	-	-	-	-
	B Deep cultivation	23.9	33.3	13.4	24.0
	C Deep plowing	27.1	46.4	24.0	18.2
	D Shallow-deep cult.	15.8	23.3	16.5	23.4
	E Check	14.4	17.6	6.3	17.1
a - Wheat in rotation	A	-	-	-	-
	B	39.0	43.5	30.0	28.0
	C (as above)	28.9	56.7	28.4	19.7
	D	16.5	46.5	48.2	25.6
	E	39.8	16.9	26.8	14.8
b - Oats in rotation	A	-	-	-	-
	B	68.4	76.1	20.9	43.2
	C (as above)	69.1	81.3	39.6	33.2
	D	23.5	48.2	58.8	49.8
	E	31.7	36.4	27.5	19.0
c - Sweet clover in rotation	A	-	-	-	-
	B	1.1	2.7	1.2	2.0
	C (as above)	2.7	1.9	1.6	2.3
	D	2.1	0.8	1.6	1.4
	E	1.0	1.0	1.0	1.6

* Alfalfa plots seeded fall of 1957. Not sampled in 1958.

Dry		III	IV	V	VI
d - Continuous	A Crested wheat**	-	-	-	-
	B Deep cultivation	6.9	4.4	10.9	4.6
	C Deep plowing	7.9	2.4	22.4	12.3
	D Shallow-deep cult.	4.9	6.3	8.5	13.5
	E Check	1.7	1.0	4.7	3.8
a - Wheat in rotation	A				
	B	10.4	8.8	5.2	5.3
	C (as above)	7.1	7.6	19.9	10.3
	D	8.8	6.3	10.3	4.6
	E	4.3	2.4	1.7	4.1
b - Oats in rotation	A				
	B	3.2	1.0	1.0	1.0
	C (as above)	1.0	1.0	5.3	14.2
	D	1.0	3.8	4.5	2.5
	E	1.0	1.0	1.7	3.9
c - Sweet clover in rotation	A	-	-	-	-
	B				
	C (as above)	No sweet clover yields.			
	D				
	E				

** Crested Wheat reseeded fall of 1957. Not sampled in 1958.

"B" Plot Yields 1959

Irrigated		Replicates			
Rotation	Treatment	I	II	III	IV
d - Continuous	A Alfalfa		Not sampled		
wheat	B Deep cultivation	13.7	20.3	29.1	23.1
Yield in bu./ac.	C Deep plowing	23.1	29.6	30.7	25.7
	D Shallow-deep cult.	14.2	21.9	26.9	26.2
	E Check	11.5	20.7	21.4	20.1
a - Wheat in	A		(as above)		
rotation	B	19.2	38.4	38.7	41.3
	C (as above)	40.3	38.7	35.6	37.5
	D	31.7	36.4	38.5	40.3
	E	29.1	27.3	28.6	30.7
b - Oats in	A		(as above)		
rotation	B	53.1	76.2	77.2	58.4
	C (as above)	64.3	66.8	62.6	101.0
	D	16.2	60.3	60.4	54.0
	E	59.2	41.7	62.4	41.3
c - Sweet clover	A				
in rotation	B				
	C (as above)		Not sampled		
	D				
	E				
Dry		III	IV	V	VI
d - Continuous	A Crested wheat				
wheat	B Deep cultivation				
	C Deep plowing		Not sampled		
	D Shallow-deep cult.				
	E Check				
a - Wheat in	A		(as above)		
rotation	B	4.0	1.4	1.8	0.5
	C (as above)	0.5	1.4	0.4	5.3
	D	0.8	1.0	2.1	5.0
	E	0.3	1.9	1.5	3.1
b - Oats in	A		(as above)		
rotation	B	4.6	0.5	2.0	2.8
	C (as above)	0.6	1.8	13.6	12.1
	D	1.6	2.2	9.1	2.9
	E	1.3	1.6	0.5	1.3
c - Sweet clover	A				
in rotation	B				
	C (as above)		Not sampled		
	D				
	E				

"B" Plot Yields 1960

		Irrigated	Replicates			
Rotation		Treatment	I	II	VII	VIII
d - Continuous	A	Alfalfa		Not sampled		
wheat	B	Deep cultivation	6.2	19.0	13.4	23.0
Yield in bu./ac.	C	Deep plowing	18.8	28.1	21.3	20.5
	D	Shallow-deep cult.	4.4	12.0	7.9	26.0
	E	Check	0.6	15.8	7.5	14.1
a - Wheat in	A			(as above)		
rotation	B		14.2	39.9	29.0	32.6
	C	(as above)	31.4	44.8	41.1	39.4
	D		9.3	27.2	32.0	39.9
	E		6.7	27.3	19.6	14.5
b - Oats in	A			(as above)		
rotation	B		23.2	50.8	70.7	80.3
	C	(as above)	51.7	67.7	77.4	79.4
	D		14.2	8.3	80.6	9.0
	E		22.5	9.4	46.8	37.1
c - Sweet clover	A					
in rotation	B					
	C	(as above)		Not sampled		
	D					
	E					
		Dry	III	IV	V	VI
d - Continuous	A	Crested wheat		Not sampled		
wheat	B	Deep cultivation	1*	1	3.1	2.9
	C	Deep plowing	1	1	9.2	6.0
	D	Shallow-deep cult.	1	1	4.7	4.8
	E	Check	1	1	2.4	4.2
a - Wheat in	A			(as above)		
rotation	B		1	1	3.3	1.6
	C	(as above)	1	1	5.2	3.1
	D		1	1	4.0	2.0
	E		1	1	-	4.4
b - Oats in	A			(as above)		
rotation	B					
	C	(as above)		Oat yields nil.		
	D					
	E					
c - Sweet clover	A					
in rotation	B					
	C	(as above)		Not sampled		
	D					
	E					

* Low yields estimated at 1 bu./ac.

"B" Plot Yields 1961

Irrigated		Replicates			
Rotation	Treatment	I	II	VII	VIII
d - Continuous wheat Yield in bu./ac.	A Alfalfa*	2.8	2.3	2.9	1.9
	B Deep cultivation	7.3	46.1[1]	1.0	23.4
	C Deep plowing	12.7	70.1[1]	2.5	21.1
	D Shallow-deep cult.	19.6	43.5[1]	8.1	25.1
	E Check	-	10.5[1]	3.8	9.7
a - Wheat in rotation	A	2.8	2.3	2.9	1.9
	B	23.0	34.9	33.8	21.0
	C (as above)	24.0	28.1	29.6	13.0
	D	16.7	34.2	36.7	6.4
	E	23.3	21.3	37.2	4.2
b - Oats in rotation	A	2.8	2.3	2.9	1.9
	B	38.9	33.2[2]	19.2	42.3
	C (as above)	20.9	35.4[2]	4.1	31.0
	D	32.9	9.4[2]	51.1	52.1
	E	19.6	7.3[2]	23.6	15.8
c - Sweet clover in rotation	A	2.8	2.3	2.9	1.9
	B	0.9	0.6	1.6	1.5
	C (as above)	1.4	1.3	1.7	2.0
	D	2.1	1.3	1.1	1.1
	E	1.3	1.0	1.6	1.1
Dry		III	IV	V	VI
d - Continuous wheat	A Crested wheat		Summerfallowed		
	B Deep cultivation		All yields rated as nil.		
	C Deep plowing				
	D Shallow-deep cult.		Not sufficient stand to sample.		
	E Check				
a - Wheat in rotation	A				
	B				
	C (as above		(as above)		
	D				
	E				
b - Oats in rotation	A				
	B				
	C (as above)		(as above)		
	D				
	E				
c - Sweet clover in rotation	A				
	B				
	C (as above)		(as above)		
	D				
	E				

* Total of 2 cuttings
[1] Oat yields
[2] Wheat yields

"B" Plot Yields 1962

Irrigated		Replicates			
Rotation	Treatment	I	II	VII	VIII
d - Continuous	A Alfalfa	14.2	25.7	6.1	13.9
wheat	B Deep cultivation	11.3	22.0	3.5	22.2
Yield in bu./ac.	C Deep plowing	5.8	19.7	4.1	12.6
	D Shallow-deep cult.	10.2	13.0	5.9	23.2
	E Check	3.7	11.2	11.8	6.5
a - Wheat in	A	22.5	8.6	18.7	13.2
rotation	B	19.6	23.7	29.1	26.0
	C (as above)	57.7	25.3	22.6	35.8
	D	34.6	30.7	27.1	24.9
	E	30.1	10.7	25.1	24.8
b - Oats in	A	46.0	90.0	29.0	47.0
rotation[1]	B	47.0	36.0	21.0	37.0
	C (as above)	28.0	43.0	24.0	27.0
	D	35.0	38.0	33.0	28.0
	E	40.0	28.0	33.0	24.0
c - Sweet clover	A	-*	-	-	-
in rotation	B	0.5	0.5	0.4	0.8
	C (as above)	0.9	0.8	0.6	0.7
	D	0.9	0.7	1.4	1.2
	E	1.2	0.4	0.6	0.7
Dry		III	IV	V	VI
d - Continuous	A Crested wheat	Not sampled. Yields estimated to be 0-5 bu./ac. in all cases. Average taken as 2.5.			
wheat	B Deep cultivation				
	C Deep plowing				
	D Shallow-deep cult.				
	E Check				
a - Wheat in	A				
rotation	B				
	C (as above)		(as above)		
	D				
	E				
b - Oats in	A				
rotation	B				
	C (as above)		(as above)		
	D				
	E				
c - Sweet clover	A				
in rotation	B				
	C (as above)		(as above)		
	D				
	E				

* Alfalfa plowed up in fall of 1961. Therefore there was no clover established for 1962 cuttings.

1 Oat yields adjusted for hail damage of 40%.

Average yields, 1954-62, of

irrigated B plots

Treatment			Replicate				Ave.of
Rotation		Cultural	I	II	VII	VIII	reps.
c - Continuous wheat	A	Alfalfa	2.0*	1.4	1.8	1.5	1.7
	B	Deep cultivation	17.6	25.1	14.9	24.9	20.6
	C	Deep plowing	20.1	30.8	17.7	23.5	23.0
	D	Shallow-deep cult.	14.1	18.6	14.2	22.5	17.4
	E	Check	8.4	20.3	13.2	16.1	14.5
		Average	15.1	23.7	15.0	21.8	18.9
a - Wheat in rotation	A		1.4	1.2	2.0	1.0	1.4
	B		29.6	36.7	31.4	28.6	31.6
	C	(as above)	34.6	36.4	28.9	31.5	32.9
	D		23.4	33.9	35.8	29.4	30.6
	E		23.7	22.2	27.4	19.5	23.2
		Average	27.8	32.3	30.9	27.3	29.6
b - Oats in rotation**	A		1.4	1.2	2.0	1.5	1.5
	B		50.3	67.6	50.1	63.8	58.0
	C	(as above)	43.3	75.1	51.8	60.5	57.7
	D		27.3	44.4	56.9	49.3	44.5
	E		41.4	32.6	47.2	36.9	39.5
		Average	40.6	54.9	51.5	52.6	49.9
c - Sweet clover in rotation***	A		1.4	1.3	1.6	1.8	1.5
	B		1.2	1.6	1.0	1.3	1.3
	C	(as above)	1.4	1.5	1.3	1.3	1.4
	D		1.3	0.8	1.2	1.0	1.1
	E		1.2	0.9	0.8	1.0	1.0
		Average	1.3	1.2	1.1	1.2	1.2

* Yields of alfalfa and sweet clover in tons per acre.
** Oats in 1957 hailed out. Figures are averages for 8 years.
*** Sweet clover sampled in only 6 of the 9 years.

Average yields, 1954-62, of

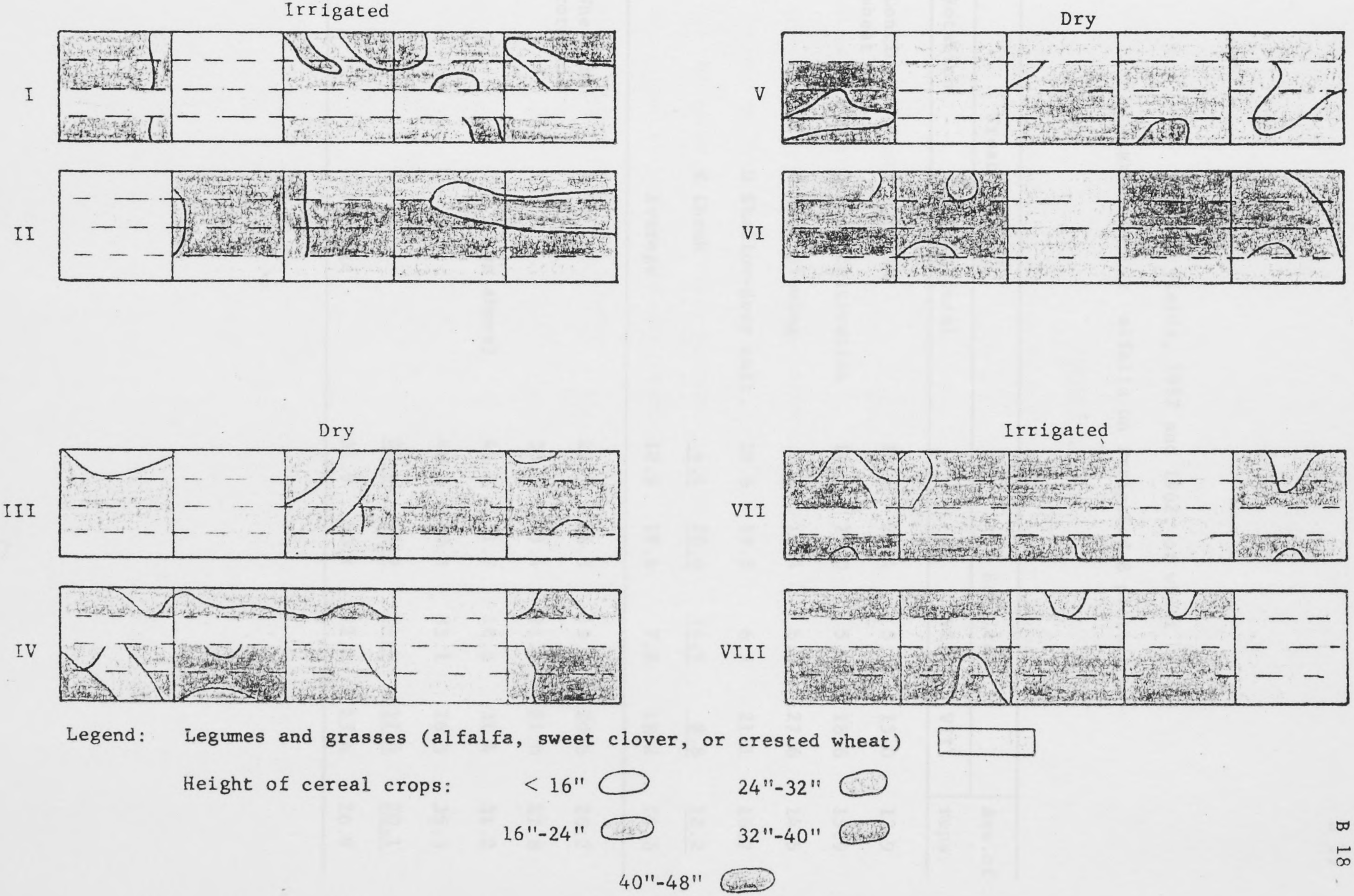
dry B plots

Treatment		Replicate				Ave.of
Rotation	Cultural	III	IV	V	VI	reps.
d - Wheat after fallow	A Crested wheat	*				
	B Deep cultivation	10.0	10.4	14.5	11.7	11.7
	C Deep plowing	11.7	8.6	21.9	15.2	14.4
	D Shallow-deep cult.	11.8	9.4	11.4	16.8	12.4
	E Check	4.9	5.3	5.2	11.0	6.6
	Average	9.6	8.4	13.3	13.7	11.3
a - Wheat in rotation	A	*				
	B	8.2	7.2	11.9	3.6	7.7
	C (as above)	4.8	6.3	13.6	10.4	8.8
	D	8.3	7.1	6.5	9.4	7.8
	E	4.6	6.2	3.3	7.6	5.4
	Average	6.4	6.7	8.8	7.8	7.4
b - Oats in rotation**	A	*				
	B	8.9	14.6	23.3	14.3	15.3
	C (as above)	14.9	18.6	18.5	20.2	18.1
	D	19.3	11.9	16.3	18.1	16.4
	E	15.2	14.5	10.1	19.1	14.7
	Average	14.6	14.9	17.1	17.9	16.1
c - Sweet clover in rotation	A	*				
	B					
	C (as above)					
	D					
	E					

* Stands of crested wheat and sweet clover very meagre in most years and not sampled.

** Oats in 1957 hailed out. Figures are averages for 8 years.

Height of wheat and oats, B plots, August 20, 1956



Average yields, 1957 and 1962, of wheat

grown after alfalfa on irrigated B plots

Treatment		Replicate				Ave.of
Rotation	Cultural	I	II	VII	VIII	reps.
- Continuous wheat	A Alfalfa	14.6	20.4	5.6	15.0	13.9
	B Deep cultivation	18.7	21.0	5.3	18.6	15.9
	C Deep plowing	7.4	16.4	6.6	27.6	14.5
	D Shallow-deep cult.	19.6	19.5	6.5	21.1	16.7
	E Check	4.4	20.6	14.9	8.8	12.2
	Average	12.9	19.6	7.8	18.2	14.6
- Wheat in rotation	A	20.3	26.3	13.4	20.6	20.2
	B	33.3	35.4	21.6	21.0	27.8
	C (as above)	43.4	31.7	18.3	31.4	31.2
	D	40.8	40.9	33.1	26.5	35.3
	E	21.6	16.9	24.6	17.4	20.1
	Average	31.9	30.2	22.2	23.4	26.9

APPENDIX C

Data on yields in C plots and other tests

Index of contents: Page

Eroded pit experiments C 2

C plot experiments C 3, C 4.

Survey of dry-land yields on farms adjacent to plots C 5

Land levelling studies

(a) Directed by Lethbridge Research Station C 6 -C 11

(b) Directed by Soil Science Department C 12

Report on survey of special farms C 13, C 14

Eroded Pit Experiments

In 1958 a number of eroded pits in the vicinity of the A plots were cultivated and prepared for a crop in 1959. Eleven chemical amendments were applied and wheat seeded. Water was applied from a portable tank. The experiment was intended as a guide to further tests. Results were as follows.

Average yields of wheat in eroded pit tests, 1959

Chemical Amendment	No. of plots	Yield in bu./ac.
Ca SO_4	4	18.9
Alum	"	16.7
Mn	"	15.7
S	"	12.7
K Cl	"	12.4
Zn SO_4	"	12.2
Coal	"	11.7
Mo	"	11.2
Check	15	11.0
Lime	4	9.4
Cu SO_4	"	7.8
Boron	"	5.6

The C Plots Experiment

The preliminary tests on isolated eroded pits during 1958 and 1959 are reported on page C 2. Results suggested that calcium sulphate, alum, and manganese sulphate might have some desirable effect on the soil in these areas. In 1960 therefore Range VIII of the former consumptive use plots (see Appendix F) was plowed and worked up and a number of chemical amendments added in strips 6 feet wide and 50 feet long. The treatments used, each of which was replicated 6 times, were:

1. Alum at 2000 lb./ac.
2. $CaSO_4.2H_2O$ at 2000 lb./ac.
3. $MnSO_4$ at 25 Mn./ac.
4. Sulphur at 2000 lb./ac
5. K_3PO_4 at 50 lb./ac.
6. $Al_2(SO_4)_3$ at 2000 lb./ac.
7. $FeSO_4$ at 2000 lb./ac.
8. Chisselling to 14" depth
9. Coal slack at 2000 lb./ac.
10. Check

In May, 1961 wheat was seeded with the following fertilizer treatments crossing all of the above plots:

A. 11-48-0 at 100 lb./ac.
B. 16-20-0 at 100 lb./ac.
C. 10-30-10 at 100 lb./ac.
D. 0-0-60 at 100 lb./ac.
E. Check

The plots were sprinkler irrigated and a three square yard sample taken at harvest time from each individual plot. Yields were as follows.

Effects of commercial fertilizers, 1961

Plot	Fertilizer	Average yield*	Inc. over check
A	11-48-0	26.9 bu./ac.	0.1
B	16-20-0	31.2 "	4.4
C	10-30-10	23.4 "	-3.4
D	0-0-60	28.7 "	1.9
E	Nil	26.8 "	-

* Average for 60 plots in each case.

Effects of chemicals, added 1960

Plot	Amendment	Ave. yield*	Inc. over check
1	Alum at 2000 lb./ac.	29.7 bu./ac.	4.4
2	$CaSO_4 . 2H_2O$ at 2000 lb./ac.	28.1 bu./ac.	2.8
3	$MnSO_4$ at 25 lb. Mn./ac.	27.6 bu./ac.	2.3
4	Sulphur at 2000 lb./ac.	26.4 bu./ac.	1.1
5	K_3PO_4 at 50 lb./ac.	22.3 bu./ac.	-3.0
6	$Al_2(SO_4)_3$ at 2000 lb./ac.	30.2 bu./ac.	4.9
7	$FeSO_4$ at 2000 lb./ac.	28.1 bu./ac.	2.8
8	Chisselling to 14" depth	30.2 bu./ac.	4.9
9	Coal slack at 2000 lb./ac.	25.8 bu./ac.	0.5
10	Check	25.3 bu./ac.	-

* Average of 30 plots in each case.

A second crop of wheat was seeded on stubble in 1962 with the same fertilizer treatments. Range cattle broke into the plots and ruined the test.

Survey of wheat yields on farms adjacent to Youngstown plots

To assess the accuracy of the measurement of yields on the unirrigated plots a survey was carried out by W. Opheim and P. Jenson. Five farms in the immediate vicinity of the plots were visited and data collected from the operators as to the average dry-land wheat yields from 1953 to 1960 inclusive. Yields recorded were for crops grown on fallow. The data are summarized in the following table:

	Farmer					Averages	
Year	A	B	C	D	E	All Farms	Farms B,C,D,E *
1953	25	15	6	11	8	13.0	10.0
1954	17	20	7	9	10	12.6	11.5
1955	25	12	8	10	8	12.6	9.5
1956	35	18	40	25	25	28.6	27.0
1957	- **	10	15	8	- **	11.0	11.0
1958	15	12	5	4	10	9.2	7.8
1959	15	16	8	8	- **	11.8	10.7
1960	15	16	8	8	- **	11.8	10.7
Ave.	21.0	13.7	12.7	11.6	11.7	13.9	12.3

* Farm A excluded because moisture regime superior to others.
** Hailed out or no data available

The above averages may now be compared with average yields from the Youngstown A and B unirrigated and irrigated plots as follows:

Average wheat yields 1953-60 on unirrigated land

(a) On five farms adjacent to Youngstown plots - 13.9 bu./ac.
(b) On four farms (B,C,D,E) - 12.3 bu./ac.
(c) On dry check areas of A plots - 13.7 bu./ac.
(d) On dry check areas of B plots - 14.2 bu./ac.

Average wheat yields 1953-60 on irrigated land

(a) A plots, best treatment (manure) - 30.9 bu./ac.
(b) B plots, best treatment (deep plowing) - 33.9 bu./ac.

Land Levelling Studies

These were undertaken by K.K. Krogman and W.L. Jacobson of the Lethbridge Research Station staff at the Youngstown experimental site. In 1954 they selected an area 350 feet by 250 feet with topography,vegetation, and soils typical of the region. Detailed surveys of the surface cover and of the topography were made. See pages C 7 and C 8. During the fall of the year the plot area was plowed, disked and levelled, and further cultivation was carried out in 1955 prior to seeding a crop of oats on June 24. The area was corrugated and irrigation carried out three times during July and August.

On September 13 and 14 three square-yard samples were taken at 25-foot intervals east and west, and north and south. Green weights are recorded on page C 9. Topography was again checked and found to be as shown on page C 10.'

The plot area was worked and again levelled and in 1956 seeded to a crop of barley, corrugated, and irrigated. Samples of the mature crop were taken following the grid pattern used in 1955. Yields obtained are shown on page C 11.

A crop in 1957, which was partially hailed out, terminated the experiments directed by the Lethbridge Station.

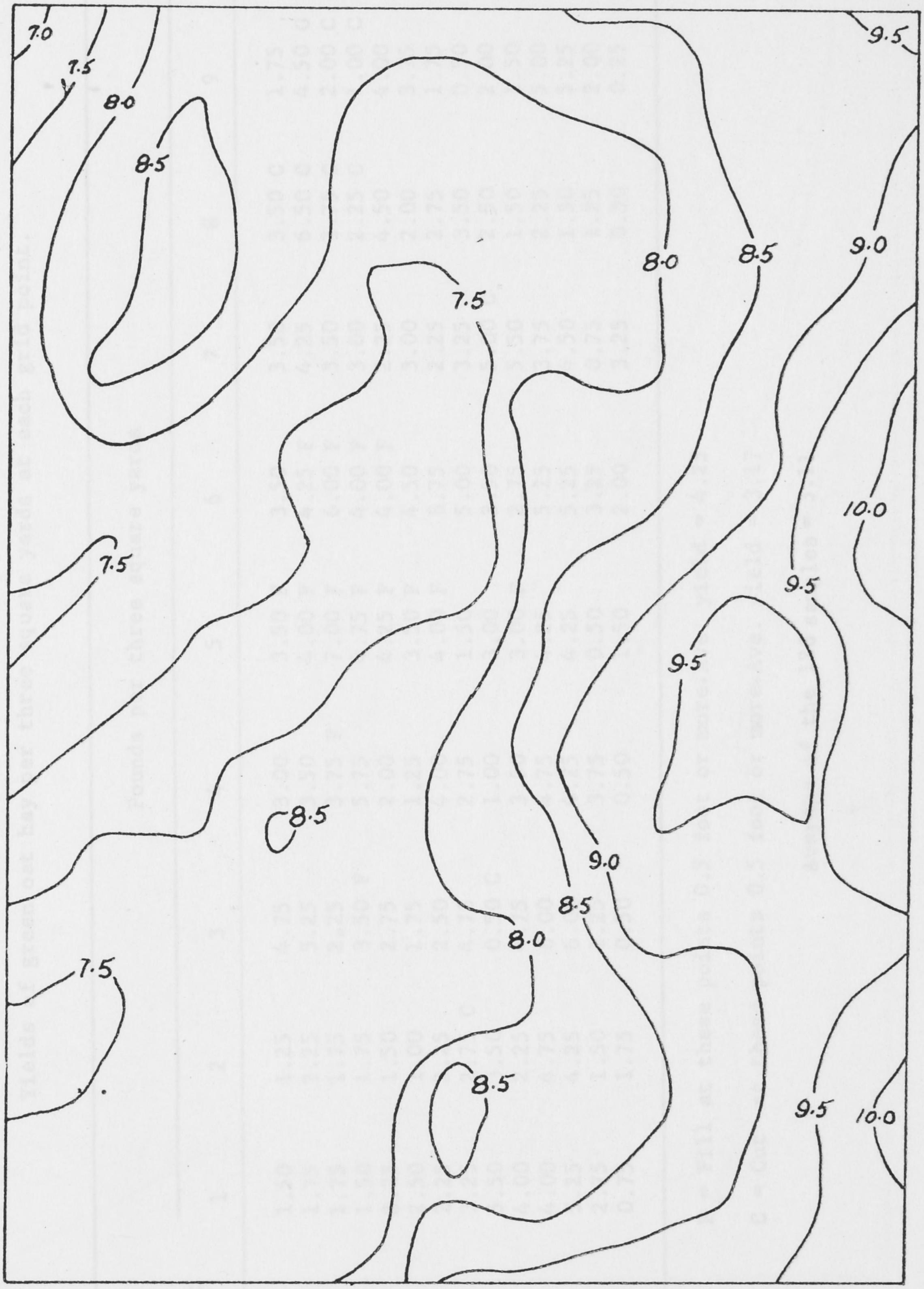
The University Soil Science Department took over the plots in 1958. After a crop of barley, for which no data were recorded, the area was seeded down to recommended pasture mixtures, the north half being designed for irrigation, the south half for dry-land. Seeding, which was done in May, 1959 was only partially successful, the stands of forage crops being very spotty and uneven. In 1960 reseeding of the bare spots was carried out. Water was applied to the irrigated half by sprinkler in 1959 and 1960 and by flood irrigation in 1961. Yield samples were collected in 1961. See page C 12. In early August of that year the irrigated half was plowed and worked and in 1962 seeded to wheat with 27-14-0 fertilizer applied at 125 lb./ac. Samples taken indicated yields as shown on page C 12.

Land Levelling Plots, 1954

Plot area, 350' x 250', showing vegetation prior to plowing

- Mainly grass
- Transitional
- Eroded areas with no vegetation

Land Levelling Plots, 1954



Contour map of plot area prior to plowing. Elevations are in feet with bench mark near upper right corner taken as 10.0'.

LAND LEVELLING STUDIES - 1955

Yields of green oat hay per three square yards at each grid point.

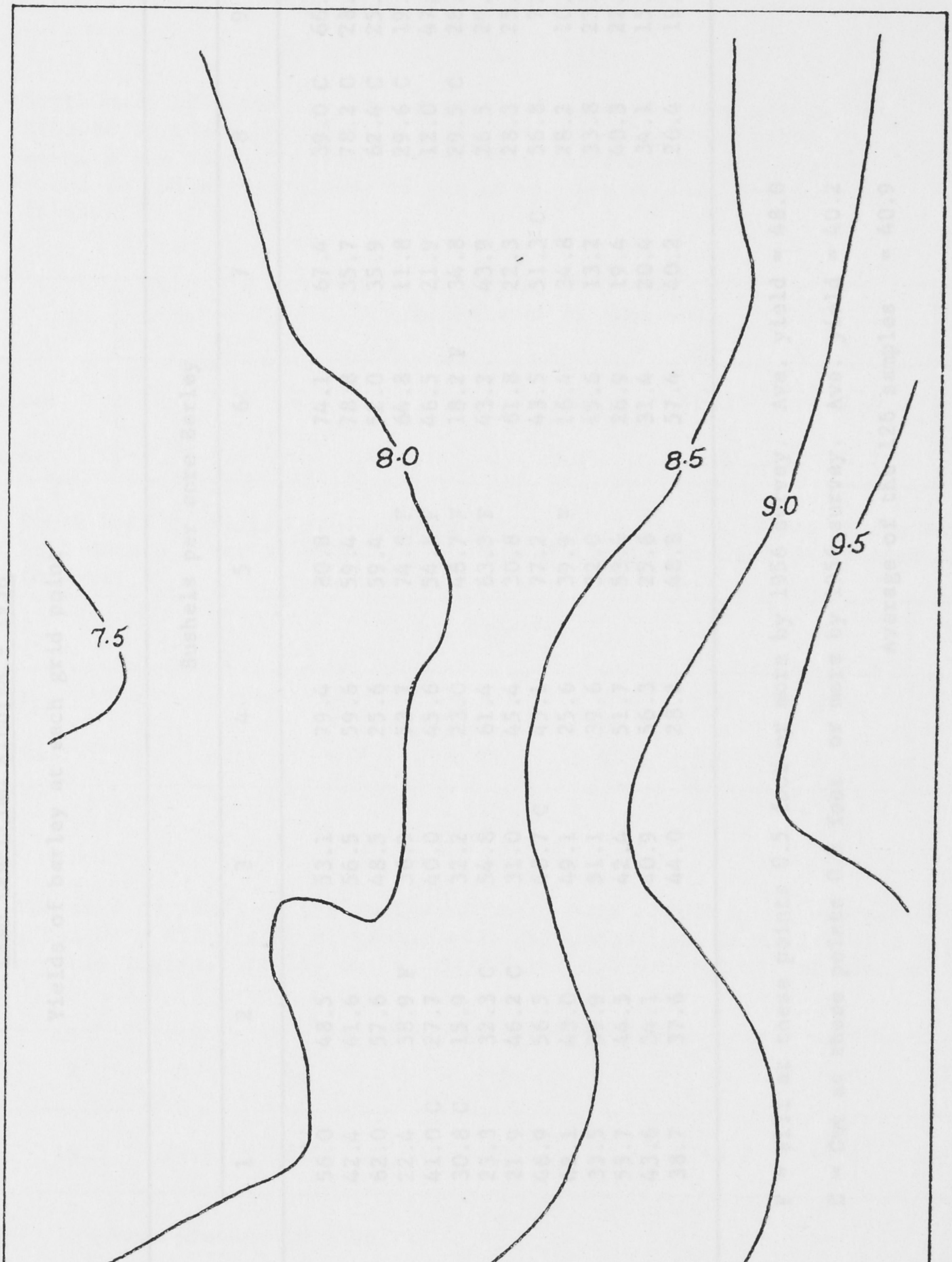
Grid Point	Pounds per three square yards								
	1	2	3	4	5	6	7	8	9
A	1.50	1.25	4.75	3.00	3.50 F	3.50	3.50	3.50 C	1.75
B	1.75	2.25	5.25	3.50	4.00 F	4.25 F	4.25	6.50 C	4.50 C
C	1.75	1.75	2.25	3.75 F	7.00 F	6.00 F	3.50	3.75 C	2.00 C
D	1.50	1.75	3.50 F	5.75	4.75 F	4.00 F	3.00	2.25 C	1.00 C
E	2.25	1.50	2.75	2.00	4.25 F	4.00 F	2.25	4.50	4.00
F	2.50	1.00	1.75	1.25	3.50 F	4.50	3.00	2.00	3.75
G	2.25	2.25	2.50	4.00	4.00 F	6.75	2.25	2.75	1.75
H	3.25	2.75 C	4.75	2.75	1.50	5.00	3.25	3.50	0.50
I	5.50	3.50	0.50 C	1.00	3.00	3.50	5.00 C	2.50	2.00
J	4.00	2.25	4.75	3.50	3.00 F	2.75	5.50	1.50	1.50
K	4.00	4.75	6.00	4.75	4.25	5.25	3.75	2.25	5.00
L	5.25	4.25	6.00	4.25	4.25	5.25	4.50	1.50	5.25
M	2.75	1.50	1.25	3.75	0.50	3.25	0.75	1.25	2.00
N	0.75	1.75	0.50	0.50	1.50	2.00	3.25	0.50	0.25

F = Fill at these points 0.5 foot or more. Ave. yield = 4.25

C = Cut at these points 0.5 foot or more. Ave. yield = 3.17

Average of the 126 samples = 3.11

Land Levelling Plots, 1955



Contour map of plot area at end of cropping season, 1955. Elevations relative to same bench mark used for map on page C 8.

LAND LEVELLING STUDIES - 1956

Yields of barley at each grid point

Grid Point	Bushels per acre Barley								
	1	2	3	4	5	6	7	8	9
A	56.0	48.5	53.1	79.4	80.8	74.1	67.4	39.0 C	66.7
B	42.4	41.6	56.5	59.6	59.4	78.8	35.7	78.2 C	28.6 C
C	62.0	57.6	48.5	25.6	59.4	52.0	35.9	62.4 C	25.8 C
D	22.4	38.9 F	36.9	53.7	74.8 F	64.8	11.8	29.6 C	19.6 C
E	41.0 C	27.7	40.0	45.6	54.1 F	46.5	21.9	12.0	47.2
F	30.8 C	15.9	32.2	23.0	46.7 F	18.2 F	34.8	29.5 C	28.8
G	23.3	32.3 C	54.8	61.4	63.3 F	43.2	43.9	26.5	29.5
H	21.9	46.2 C	31.0	45.4	30.8	61.8	22.3	28.3	25.3
I	46.9	56.5	48.7 C	45.1	77.2	43.5	51.3 C	56.8	7.8
J	42.1	43.0	49.1	25.6	39.9 F	16.4	34.8	28.2	10.4
K	33.5	39.9	51.1	39.6	32.0	45.6	13.2	33.8	23.9
L	55.7	44.5	42.4	51.7	53.4	26.9	19.4	40.3	22.8
M	43.6	34.1	40.9	56.3	25.6	31.4	20.4	34.1	15.3
N	38.7	37.6	44.0	28.2	48.8	57.4	40.2	26.4	19.1

F = Fill at these points 0.5 foot or more by 1956 survey. Ave. yield = 48.0

C = Cut at these points 0.5 foot or more by 1956 survey. Ave. yield = 40.2

Average of the 126 samples = 40.9

Yields on Land Levelling Plots

1961

(a) North half of plots, producing mainly a crop of brome grass, was allowed to reach advanced maturity. Six samples were taken to measure the range in productivity from the poorest part of the stand to the best. Yields of the green, but mature, hay were as follows.

	Sampled area in each case 5' x 15'					
	1	2	3	4	5	Ave.
Lb./cut	1.5	2.5	11.0	12.0	14.0	
Tons/ac.	0.4	0.7	3.2	3.5	4.1	2.4

(b) South half of plots, producing only a crop of crested wheat grass, also at a mature stage of growth, and sampled in similar fashion yielded as follows:

	Samples						
	1	2	3	4	5	6	Ave.
Lb./cut	0.5	2.5	3.0	3.5	4.0	5.5	
Tons/ac.	0.14	0.7	0.9	1.0	1.2	1.6	0.92

1962

The crop of wheat on the irrigated north half of the plots was sampled by taking ten 3' x 25' strips at random over the whole area to arrive at a representative yield figure. Yields in bu./ac. of the ten sampled strips were as follows:

1	2	3	4	5	6	7	8	9	10
17.7	19.5	24.6	26.4	27.1	27.8	32.9	36.0	46.8	48.1

Ave. yield = 30.7 bu./ac.

The crop of crested wheat on the unirrigated south half of the land levelling plots was extremely poor and estimated at 0.25 ton per acre.

Report on survey of special farms, 1953

Early in the development of the Youngstown irrigation experiments the government was urged by the East Central Irrigation Association to contact farmers "who have had successful experience" with solonetz soils both as dry land farmers and as local irrigation projects. The following farmers were specifically named in a letter dated May 20, 1953, and addressed to Dr. O. S. Longman:

Wade Brothers	-	Consort
George Kropinski	-	Consort
Ralph Thornton	-	Sedalia
Emil Kowalski	-	Youngstown
J. A. Cameron	-	Youngstown
Lyall Currie	-	Carolside
Magnus Bjork	-	Atlee
Bruce Dawson	-	Atlee
V-V Ranch	-	east of Wardlow
C. Anderson	-	Brooks

The Association further stated in their letter, "that experienced farmers in the Youngstown area did not consider that the piece of land chosen for the experimental plot there is a true average of the lands to be tested. They view it as one of the poorest pieces of land in the district, and one where irrigation would be least likely to succeed". To check on these claims and to discover what success farmers were having on the Hemaruka soil a survey was obviously necessary.

In 1953 Dr. A. L. Mathieu visited each of these farms and interviewed the operator. He prepared a detailed report on their farming operations with particular regard to soil management and any irrigation being done. The reports need only be summarized at this point.

Abstracts of A. L. Mathieu's reports, 1953

Wade Brothers Farm, Consort

No irrigation is done on this farm. The soil is solonetzic but not as tough as the Hemaruka soil of the Youngstown plots. Some novel and apparently successful techniques in dry-land farming have been worked out here.

Mr. George Kropinski's Farm, Consort

Approximately 60 acres of land are irrigated by sprinkler system. The soil is a loam and is not a solonetz.

Mr. Ralph Thornton's Farm, Sedalia

Irrigates about 5-10 acres of pasture land and a garden, by free flooding. The soil has a hard pan and is classed as Hemaruka, but the irrigated area is quite small, and is mainly pasture.

Mr. Emil Kowalski's Farm, Youngstown

Irrigates about 20-40 acres by sprinkler system. The soil has a hard pan and was classified as blow-out (Hemaruka) loam. Mr. Kowalski found that this soil became very hard and impervious after irrigation, and so he divided the 40 acre field into 2 portions and now irrigates alternate 20-acre fields each year.

Mr. J. A. Cameron's Farm, Youngstown

Irrigates only orchard and potatoes. The soil on the Cameron farm varies from a sandy loam to a loam and it is not a Hemaruka soil.

Mr. Lyall Currie's Ranch, Sunnybrook

Approximately 50 acres of land are irrigated by sprinkler system. The surface soil on irrigated land varies from a sandy loam to a loam, while the subsoil is quite sandy, permitting good drainage. There was no evidence of any solonetz characteristic.

Mr. Magnus Bjork's Ranch, Atlee

Irrigates approximately 150 acres of river flat land by flooding method. This soil can be classified as alluvial and varies from a loam to a silt loam. It is not solonetzic.

Mr. A. B. Dawson's Ranch, Atlee

Irrigates approximately 100 acres, all by sprinkler system. This soil is a silty loam, similar to Bjork's and has good drainage. It is not solonetzic.

V-V Ranch owned by Credit Foncier and Managed by Keith Acton, Wardlow

Approximately 370 acres of river flat land are irrigated by the flooding method. Penetrometer readings indicate that this irrigated land is alluvial loam. The probe was easily pushed to a depth of 3' - 4' in the alfalfa field. This is not Hemaruka soil.

APPENDIX D

Chemistry of the Youngstown plot soils

Index of contents:

Index of contents:	Pages
Conductivity of A plot soils	D 2
Salinity data for B plots	D 3
Krogman and Milne data on Hemaruka soils	D 4
Exchangeable cations in Hemaruka and other solodized-solonetz soils	D 5
Exchangeable cations in A plot soils	D 6 - D 10
Data on quality of water used in irrigation experiments at Youngstown compared with other irrigation waters in Alberta	D 11, D 12

Conductivity of A plot soils

Conductance of soils in plots 1-21 of Replicate I, relative to depth, as measured by Solu Bridge. Units are millimhos/cm. Readings below 4.0 are usually considered as evidence of no serious salinity problem in the soil. When readings are between 4.0 and 8.0 most crops are restricted in growth.

Plot No.	Depth 0 - 1'	1 - 2'	2 - 3'	3 - 4'
1	3.8	4.3	7.8	7.5
2	2.5	0.8	0.9	2.0
3	3.1	2.8	5.0	8.0
4	4.7	8.5	5.8	3.5
5	5.5	3.8	6.0	5.5
6	4.6	5.2	5.4	4.8
7	2.5	3.4	4.9	2.2
8	8.0	8.0	5.5	4.5
9	8.0	4.0	7.6	6.2
10	2.6	6.2	6.2	6.1
11	1.0	1.7	1.4	5.4
12	4.7	6.0	4.8	5.8
13	5.0	6.5	6.0	7.0
14	5.5	8.5	2.2	5.2
15	4.6	9.0	5.5	7.9
16	3.7	7.4	8.3	6.2
17	6.0	7.6	3.4	9.5
18	1.1	7.1	4.0	5.8
19	1.5	2.0	0.5	4.2
20	3.0	4.8	6.6	5.9
21	2.5	1.7	2.4	5.0
Average	4.0	5.2	4.8	5.6

Salinity data for B plots

In 1954 king tube samples were collected from one-foot layers to a depth of four feet at four points near the centre of each plot in Replicates I, II, VII and VIII. (See page B 3). The degree of salinity was determined by a soil paste method using a Bouyoucos Bridge, Model C. Resistance readings were classified as follows:

Over 400 ohms	-	No salinity problem
190 - 400 ohms	-	Weak alkali
130 - 190 ohms	-	Moderately strong alkali
80 - 130 ohms	-	Strong alkali
Less than 80 ohms	-	Very strong alkali

In the 80 plots thus tested the prevalence of alkali was found to be as indicated in the following tables.

Percentages of plots with no salinity problem

	First foot	Second foot	Third foot	Fourth foot
Rep. I	21	23	5	5
Rep. II	11	11	10	5
Rep. VII	18	11	15	5
Rep. VIII	20	5	6	0

Percentages of plots with readings under 190 ohms
(This includes soils with alkali problems classified above as "moderately strong" to "very strong")

	First foot	Second foot	Third foot	Fourth foot
Rep. I	47	59	70	75
Rep. II	17	58	70	75
Rep. VII	44	72	70	85
Rep. VIII	40	53	83	85

Conductivity measurements of other soils

Electrical conductivities of saturation extracts and sodium adsorption ratios were reported by Krogman and Milne (Can. J. Soil Sci. 41: 188-195. 1961) for four locations each of non-irrigated Hemaruka, irrigated Hemaruka, and irrigated Halladay soils. Average values reported were as follows.

	$EC \times 10^3$			S A R *		
Depth (feet)	Non-irrigated Hemaruka	Irrigated Hemaruka	Irrigated Halladay	Non-irrigated Hemaruka	Irrigated Hemaruka	Irrigated Halladay
0-0.5	0.6	4.7	1.1	4.0	18.6	2.0
0.5-1	1.6	5.6	0.6	9.0	20.8	0.5
1-2	4.1	10.8	1.4	15.8	22.3	1.0
2-3	7.2	11.7	2.5	16.7	23.1	8.0
3-4	7.0	9.7	1.4	20.9	22.1	3.0
4-5	9.7	10.2	3.4	19.8	21.9	13.5
5-6	8.7	8.2	5.0	19.8	18.2	10.2'
6-15	7.6	6.4	5.4	19.8	15.3	16.9

$$* \text{ S A R} = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

S A R values in excess of 13.8 (which corresponds to an exchangeable sodium percentage of 15) indicate a particularly troublesome type of alkali which is difficult to counteract.

Exchangeable cations

For his Ph.D. thesis A.L. Mathieu reported the exchangeable cations and cation exchange capacities of Hemaruka, Echo and Trossachs soils. The first two are solodized-solonetz soils of the Brown Soil Zone while the last named is in the Dark Brown Zone. The Echo and Trossachs occur in Saskatchewan. The data reported were as follows.

Profile	Horizon	Exchangeable cations (per cent)					Cation exchange capacity me./100 g.
		Na	Mg	Ca	K	H	
Hemaruka	A 1	4	15	35	4	42	6.9
	A 21	4	19	23	2	52	5.3
	A 22	28	28	16	5	23	3.9
	B 11	40	40	13	7	0	19.2
	B 12	45	38	11	6	0	21.9
Echo	A 1	8	20	34	1	37	20.0
	A 21	2	23	16	4	55	11.6
	A 22	7	36	9	4	44	7.0
	B 11	19	69	7	5	0	21.0
	B 12	17	66	12	5	0	26.5
Trossachs	A 1	0	24	44	7	25	18.5
	A 21	7	33	35	3	22	12.2
	A 22	12	44	25	3	16	9.1
	B 11	21	67	8	4	0	20.3
	B 12	17	69	10	4	0	23.6

Exchangeable cations and total exchange capacity of A plot soils

Replicate I

Treat-ment	1952 Na	1952 Cation (per cent) Mg	1952 Ca	1952 K	1952 H	1952 Sum of cations (me./100 gm.)	1952 T.E.C.	1959 Na	1959 Cation (per cent) Mg	1959 Ca	1959 K	1959 H	1959 Sum of cations (me./100 gm.)	1959 T.E.C.
Block A														
S	10.0	31.5	54.0	3.2	1.4	21.6	17.0	9.6	33.4	51.2	5.1	.6	15.6	16.4
K	19.7	25.0	52.0	3.1		25.9	12.3	19.5	33.6	36.5	3.1	7.3	16.4	15.1
G	2.2	25.0	55.0	3.3	14.4	18.1	15.5	8.1	25.7	54.0	3.4	8.8	14.8	16.7
M	3.6	19.8	74.0	2.8		27.8	13.1	13.6	23.4	60.8	2.4		20.6	16.2
DC	26.8	26.8	44.0	2.3		29.9	18.4	22.6	23.9	51.4	2.2		23.0	13.8
IC	22.2	27.0	42.6	2.7	5.4	18.5	15.6	23.7	22.7	50.0	3.6		22.0	15.5
Dry	22.4	33.9	39.5	2.2	2.2	13.9	8.0	23.9	25.5	48.6	2.1		24.3	14.5
Block B														
S	17.5	14.6	67.2	1.0		49.2	15.0	5.9	14.1	78.6	1.4		36.9	12.4
K	13.8	25.8	52.5	2.3	5.8	17.4	14.0	21.8	26.3	43.8	3.1	5.0	16.0	17.4
G	29.8	30.4	37.6	2.3		21.8	14.4	23.3	19.4	54.8	2.4		20.6	13.0
M	28.2	18.4	52.4	1.3		39.2	15.9	19.3	23.1	55.8	1.9		26.0	17.6
DC	23.4	30.2	44.0	2.6		23.2	14.2	15.3	24.5	57.6	2.5		19.6	13.2
IC	33.2	35.6	27.0	4.3		21.1	15.4	20.3	19.2	55.3	3.7	1.5	27.1	13.0
Dry	7.9	20.7	70.0	1.6		31.5	15.0	9.4	21.2	68.3	0.9		21.2	16.4
Block C														
S	27.4	28.7	40.0	4.1		17.2	12.7	23.4	27.8	40.2	7.3	1.5	13.7	13.9
K	22.1	18.9	56.8	1.5		43.3	12.7	15.2	19.6	63.0	2.2		23.0	15.5
G	21.4	24.2	52.7	1.8		28.1	15.9	18.4	22.2	57.5	1.9		26.1	16.1
M	18.2	24.8	54.5	2.5		24.2	11.3	19.8	28.4	44.0	5.7	2.1	14.1	15.0
DC	13.8	26.5	50.5	3.6	5.4	16.6	14.5	16.8	16.8	63.5	2.8		17.8	12.2
IC	3.4	16.8	77.3	2.7		29.8	12.8	6.7	17.1	74.0	2.2		22.3	14.2
Dry	35.8	29.4	25.8	4.2	4.6	19.0	14.0	35.4	25.6	31.7	6.1	1.2	16.4	14.8
Ave.	19.2	25.4	50.9	2.6	1.9	25.6	14.2	17.7	23.5	54.3	3.1	1.3	20.8	14.9

Exchangeable cations and total exchange capacity of A plot soils

Replicate II

Treatment	1952 Na	Mg	Ca	K	H	Sum of cations (me./100 gm.)	T.E.C.	1959 Na	Mg	Ca	K	H	Sum of cations (me./100 gm.)	T.E.C.
Block A														
S	18.9	20.3	59.5	1.4		34.5	14.8	15.2	26.0	56.8	2.0		25.0	15.5
K	27.2	34.2	33.0	2.4	2.8	20.9	17.9	30.2	38.4	28.5	2.9		17.2	18.8
G	28.8	29.8	38.0	3.3		24.2	14.6	29.1	34.0	33.0	3.9		20.6	17.1
M	15.3	26.4	55.6	2.8		21.6	15.9	12.2	25.4	59.1	3.2		24.5	17.0
DC	12.3	28.8	57.0	2.1		24.3	17.0	15.3	31.7	50.2	2.7		18.3	16.4
IG	3.3	27.1	53.0	4.4	12.2	18.1	15.9	7.3	23.3	65.6	2.4		20.3	15.6
Dry	25.8	36.4	35.1	2.7		22.5	20.7	41.6	31.1	22.8	2.6	2.1	19.3	18.7
Block B														
S	37.0	35.0	18.3	4.1	5.6	19.7	14.5	32.4	40.0	23.6	2.9	1.2	17.0	16.8
K	34.5	24.4	37.2	3.6	.3	27.5	15.1	34.6	29.8	32.7	2.4	0.5	20.8	17.1
G	4.8	26.4	53.2	4.8	10.8	16.7	14.8	12.9	27.3	41.7	5.7	12.2	13.9	13.8
M	39.5	25.8	31.4	2.3	.9	21.3	16.8	38.1	32.0	27.6	1.2	1.2	16.3	15.8
DC	19.2	40.6	31.6	3.2	5.4	18.7	18.4	23.4	40.6	29.8	1.6	4.7	12.8	13.8
IC	17.1	36.2	42.4	1.9	2.4	20.5	20.4	24.2	36.6	37.7	1.1	0.5	18.6	19.6
Dry	2.1	25.6	68.2	4.2		24.2	15.4	3.5	25.0	68.0	3.5		23.2	15.8
Block C														
S	26.9	25.9	24.8	3.1	19.2	19.3	14.5	31.6	32.9	24.0	1.3	10.1	15.8	16.1
K	4.0	25.3	66.6	4.0		19.8	13.5	12.4	28.9	55.2	3.4		14.5	15.2
G	1.9	24.1	72.0	1.9		20.8	15.7	5.2	21.9	70.3	2.6		19.2	15.0
M	22.2	35.2	31.4	4.6	6.5	15.3	12.6	16.9	33.2	45.2	4.8		16.6	15.5
DC	23.3	33.1	30.7	4.9	8.0	16.3	13.0	29.5	27.9	33.1	1.5	8.1	13.6	14.6
IC	19.5	21.9	36.1	5.3	17.2	16.9	15.6	34.5	26.5	27.9	3.3	8.0	15.1	15.8
Dry	30.3	27.8	37.0	3.3	1.7	24.1	13.7	31.2	31.2	36.5	1.0		19.2	15.6
Ave.	19.7	29.5	43.4	3.3	4.4	21.3	15.8	22.9	30.7	41.4	2.7	2.4	18.2	16.2

Exchangeable cations and total exchange capacity of A plot soils

Replicate III

Treat-ment	1952 Na	Cation (per cent) Mg	Ca	K	H	Sum of cations (me./100 gm.)	T.E.C.	1959 Na	Cation (per cent) Mg	Ca	K	H	Sum of cations (me./100 gm.)	T.E.C.
Block A														
S	13.8	31.6	49.5	3.3	9.3	26.9	12.8	11.3	28.4	52.0	7.5	.9	10.6	14.8
K	6.5	39.2	45.6	5.9	2.6	18.6	17.5	10.3	37.7	46.6	5.5		14.6	16.1
G	16.3	31.4	31.4	3.3	17.7	15.3	17.7	22.6	31.1	40.2	1.3	7.8	15.9	17.7
H	21.0	29.8	42.0	3.8	3.4	23.8	27.6	26.3	30.3	37.9	4.0	1.5	19.8	21.7
DC	4.6	30.8	60.8	3.9		26.0	18.7	6.5	33.7	55.4	4.3		18.4	18.7
IC	11.0	24.8	50.2	5.0	8.8	18.1	16.6	22.0	25.2	39.4	3.9	9.4	12.7	14.2
Dry	24.6	27.9	44.3	3.3		30.5	20.2	33.0	37.0	25.6	4.5		17.6	18.6
Block B														
S	3.2	22.2	64.5	7.6	2.5	15.8	12.8	13.5	42.0	40.5	1.3	2.7	14.8	18.3
K	15.9	51.6	29.8	2.4	0.4	25.2	20.6	20.7	34.4	38.5	3.0	3.6	16.9	18.8
G	8.3	25.8	64.0	2.7		21.7	16.3	21.6	37.0	40.0	1.2		16.2	17.0
H	1.0	19.8	48.7	10.0	20.0	19.7	17.1	9.1	27.2	45.5	7.3	10.9	11.0	13.4
DC	8.7	24.0	38.0	4.0	25.4	15.0	14.5	16.6	26.5	37.9	3.8	15.1	13.2	13.9
IC	20.4	30.2	43.0	2.8	3.3	21.5	19.9	28.2	34.0	34.0	1.1	2.8	17.7	19.0
Dry	7.6	48.0	34.2	3.1	7.1	19.6	19.0	14.3	35.7	42.2	1.3	6.5	15.4	17.7
Block C														
S	26.2	31.8	36.0	2.3	3.7	21.4	14.9	30.0	31.2	30.0	1.2	7.5	16.0	14.2
K	35.6	31.3	30.5	2.7		25.9	16.7	38.1	32.8	26.4	2.6		18.9	16.2
G	27.8	35.8	25.2	4.6	6.6	15.1	14.3	39.0	5.5	42.0	5.5	7.8	9.0	14.2
H	16.8	27.0	41.6	5.1	9.5	13.7	12.1	26.3	32.9	32.9	5.2	2.0	15.2	15.5
DC	6.9	26.8	57.4	3.8		24.8	10.5	8.7	28.1	60.1	2.4		20.6	15.4
IC	20.5	30.5	40.5	3.8	4.8	21.0	19.6	32.2	32.2	33.3	1.1	1.1	18.0	20.2
Dry	31.6	32.0	31.6	4.0	.9	22.5	19.3	34.3	32.6	26.8	4.7	1.8	16.9	16.7
Ave.	15.6	31.1	43.3	4.2	6.0	21.0	17.1	22.1	31.2	39.4	3.5	3.9	15.7	16.8

Exchangeable cations and total exchange capacity of A plot soils

Replicate IV

Treatment	1952 Cation (per cent) Na	Mg	Ca	K	H	Sum of cations (me./100 gm.)	T.E.C.	1959 Cation (per cent) Na	Mg	Ca	K	H	Sum of cations (me./100 gm.)	T.E.C.
Block A														
S	15.6	34.1	45.0	5.1	.3	31.4	27.6	9.3	35.2	42.5	7.8	5.2	19.3	21.9
K	15.0	34.4	45.5	5.1		31.4	27.1	14.1	32.1	48.0	5.7		21.2	23.2
G	0.6	22.9	65.0	5.7	5.7	17.5	15.8	3.0	17.0	74.0	6.0		16.5	14.1
M	16.9	29.4	40.0	7.3	6.2	17.7	17.2	25.3	27.1	36.2	9.0	2.4	16.6	17.5
DC	18.2	33.8	39.5	5.1	3.5	25.3	25.2	20.3	31.5	42.5	5.8		20.7	21.9
IC	16.6	26.5	37.0	6.1	13.6	13.2	11.7	26.6	22.1	35.5	8.8	7.1	11.3	11.6
Dry	27.9	26.8	38.0	6.7	.7	26.9	20.0	30.8	27.5	33.1	8.5		21.1	20.4
Block B														
S	0.6	22.2	66.0	6.2	4.9	16.2	14.8	4.7	18.6	71.0	5.8		17.2	12.3
K	2.1	29.7	61.0	7.4		24.3	18.7	4.7	32.3	56.0	7.1		17.0	17.2
G	3.5	17.6	38.0	8.0	32.8	11.3	10.4	22.9	27.6	27.6	11.0	11.0	10.9	10.4
M	34.9	34.4	22.8	7.7		20.6	13.7	5.3	21.3	65.0	8.0		15.0	13.6
DC	17.0	25.8	41.0	8.2	8.2	14.7	10.3	22.4	30.4	38.8	9.6	4.0	12.5	10.8
IC	0.8	26.6	68.2	4.5		26.4	18.1	3.7	25.8	66.0	4.6		21.5	15.5
Dry	22.3	28.7	45.2	3.8		31.4	24.1	20.6	27.8	46.8	4.8		25.2	19.6
Block C														
S	8.3	31.4	42.0	5.9	12.5	16.9	15.4	10.3	27.6	36.2	8.6	17.3	11.6	12.2
K	29.7	29.7	35.6	5.0		23.9	21.4	31.0	33.6	29.0	6.5		15.5	16.7
G	7.9	44.0	44.0	4.4		22.8	20.3	7.5	50.4	36.6	3.1	2.5	15.9	19.2
M	18.7	24.0	28.9	4.9	2.4	19.4	15.1	24.0	28.0	25.6	9.6	12.8	12.5	11.6
DC	31.0	32.8	25.6	5.4	5.4	16.8	13.4	26.3	32.9	26.3	6.6	7.9	15.2	14.5
IC	20.7	30.8	39.8	5.6	3.1	15.9	14.8	26.7	29.0	32.1	6.1	6.1	13.1	13.1
Dry	8.6	20.3	68.4	1.8		55.6	24.8	23.4	42.1	32.2	1.2	1.2	17.1	20.3
Ave.	15.1	28.9	44.6	5.7	4.7	22.8	18.1	17.3	29.5	42.9	6.9	3.7	16.5	16.1

Summary of exchangeable cation data

Averages for A plot soils sampled in 1952 and 1959

and analyzed by slightly different techniques

1952 samples

(a) As per cent of total (b) As me./100 gm.

	Na	Mg	Ca	K	H	Na	Mg_1	Ca_1	K	H	Total
S	17.4	26.1	50.0	3.3	3.3	4.2	6.3	12.0	0.8	.8	24.1
K	19.8	30.0	45.8	3.6	0.8	5.0	7.6	11.6	.9	.2	25.3
G	13.8	28.2	48.7	3.6	5.6	2.7	5.5	9.5	.7	1.1	19.5
M	20.3	25.7	45.9	4.5	3.6	4.5	5.7	10.2	1.0	.8	22.2
DC	17.2	30.1	45.0	3.8	3.8	3.6	6.3	9.4	.8	.8	20.9
IC	14.9	27.4	48.8	4.0	5.0	3.0	5.5	9.8	.8	1.0	20.1
Dry	19.0	28.2	48.3	3.3	1.1	5.1	7.6	13.0	.9	.3	26.9
Ave.*	17.2	27.8	47.4	3.9	3.7	3.8	6.1	10.4	.8	.8	22.0

1959 samples

(a) As per cent of total (b) As me./100 gm.

	Na	Mg	Ca	K	H	Na	Mg_1	Ca_1	K	H	Total
S	15.6	27.9	49.2	3.9	3.3	2.8	5.0	8.8	.7	.6	17.9
K	21.5	31.1	42.4	4.0	1.1	3.8	5.5	7.5	.7	.2	17.7
G	17.5	27.1	49.4	3.6	2.4	2.9	4.5	8.2	.6	.4	16.6
M	19.5	27.6	46.0	4.6	2.3	3.4	4.8	8.0	.8	.4	17.4
DC	17.9	28.3	46.8	4.0	2.9	3.1	4.9	8.1	.7	.5	17.3
IC	20.1	25.5	48.4	3.3	2.7	3.7	4.7	8.9	.6	.5	18.4
Dry	24.4	29.4	41.6	3.6	1.0	4.8	5.8	8.2	.7	.2	19.7
Ave.*	18.7	27.7	47.0	3.9	2.4	3.3	4.9	8.2	.8	.4	17.5

* Averages of the six irrigated treatments only.

1 Versene procedure used in 1952, flame photometer in 1959.

Water Quality

(Data provided by P.F.R.A. Drainage Division, Vauxhall).

Source of water	Date	pH	Cond. Micromhos	ppm.	Soluble salts in me./1. Na	Ca + Mg	SO_4	CO_3	HCO_3	Cl	SAR	Res. Na_2CO_3	Water class*
Youngstown plots	July/57	7.8	366	234	1.5	1.8	1.3	-	2.1	0.2	1.6	0	C2 S1
Carolside dam	"	8.2	304	195	1.3	1.8	1.7	-	1.7	0.1	1.4	0	"
Neismith dam	"	8.3	1961	1255	12.4	5.3	18.9	-	4.8	0.2	7.6	0	C3 S2
Red Deer river	"	8.3	369	236	0.7	4.8	3.4	-	3.1	0.1	0.5	0	C2 S1
Bassano dam	June/57	8.2	300	192	0.2	2.7	0.5	-	2.7	0.3	0.2	0.6	"
	Aug./57	7.3	284	181	0.3	4.5	2.5	0.7	1.4	0.2	0.2	0	"
Lake McGregor	May/57	8.1	600	384	2.2	4.0	2.8	0.5	3.2	0.2	1.6	0	"
	Aug./57	7.7	373	239	1.3	2.8	1.5	0.5	1.9	0.1	1.0	0	"
St. Mary's Res.	May /57	8.0	300	192	0.4	2.5	0.3	0.4	2.4	0.1	0.4	0.3	"
	Aug./57	7.2	241	154	0.3	2.0	0.2	tr.	2.2	0.0	0.3	0.2	C1 S1

* Symbols currently in use by U.S.D.A. for indication of water quality. Defined as follows:

C1 - Low salinity water
C2 - Medium salinity water
C3 - High salinity water
C4 - Very high salinity water

S1 - Low-sodium water
S2 - Medium-sodium water
S3 - High-sodium water
S4 - Very high sodium water

Water Quality

Analytical data provided by Provincial Analyst

on water samples collected in 1954.

All data in parts per million

Sample	Total solids	Ignition loss	Hardness	Sulphates	Chlorides	Alkalinity	Nature of alkalinity	Nitrites	Nitrates	Iron
Bartman Dam	626	162	165	128	8	290	Na,Ca,Mg,-HCO_3	T	0.4	4.5
Carolside Dam	340	90	80	90	2	120	Na,Ca,Mg,-HCO_3	T	0.8	1.5
Deadfish Dam	1912	220	485	850	11	300	Ca,Mg HCO_3	-	-	0.2
Youngstown Plots Dam	312	96	80	88	3	90	Ca,Mg HCO_3	T	0.8	1.5
Red Deer River*	186	112	125	7	1	110	Ca,Mg HCO_3	-	-	0.5

* Sample taken at Red Deer, May 11, 1954.

Appendix E

Physical studies of Youngstown plot soils

Index of contents:

Index of contents	Pages
Mechanical analyses of A plots	E 2 - E 5
Porosity and permeability	E 6 - E 7
Aggregate analyses, 1953	E 8
Aggregate analyses, 1959	E 9
Penetrometer studies	E 10
Penetrometer data for A plots	E 11, E 12
Penetrometer data for B plots	E 13, E 14

Mechanical analysis of 0-4" samples

Note:- single samples taken from A plots (See page A 3)

	Replicate I			Replicate II		
Plot	Sand	Silt	Clay	Sand	Silt	Clay
1*	39%	43%	18%	41%	49%	10%
2	39	43	18	38	49	13
3	45	40	15	40	46	14
4	57	35	8	42	40	18
5	58	33	9	50	36	14
6	58	24	18	50	35	15
7	54	31	15	46	39	15
8	51	33	16	41	42	17
9	50	31	19	42	41	17
10	53	28	19	40	42	18
11	46	33	21	48	37	15
12	54	32	14	54	37	9
13	52	35	13	47	39	14
14	54	32	14	47	39	14
15	56	29	15	44	36	20
16	57	28	15	49	35	16
17	52	32	16	48	34	18
18	58	29	13	48	36	16
19	52	31	17	41	40	19
20	56	31	13	45	38	17
21	59	30	11	47	36	17

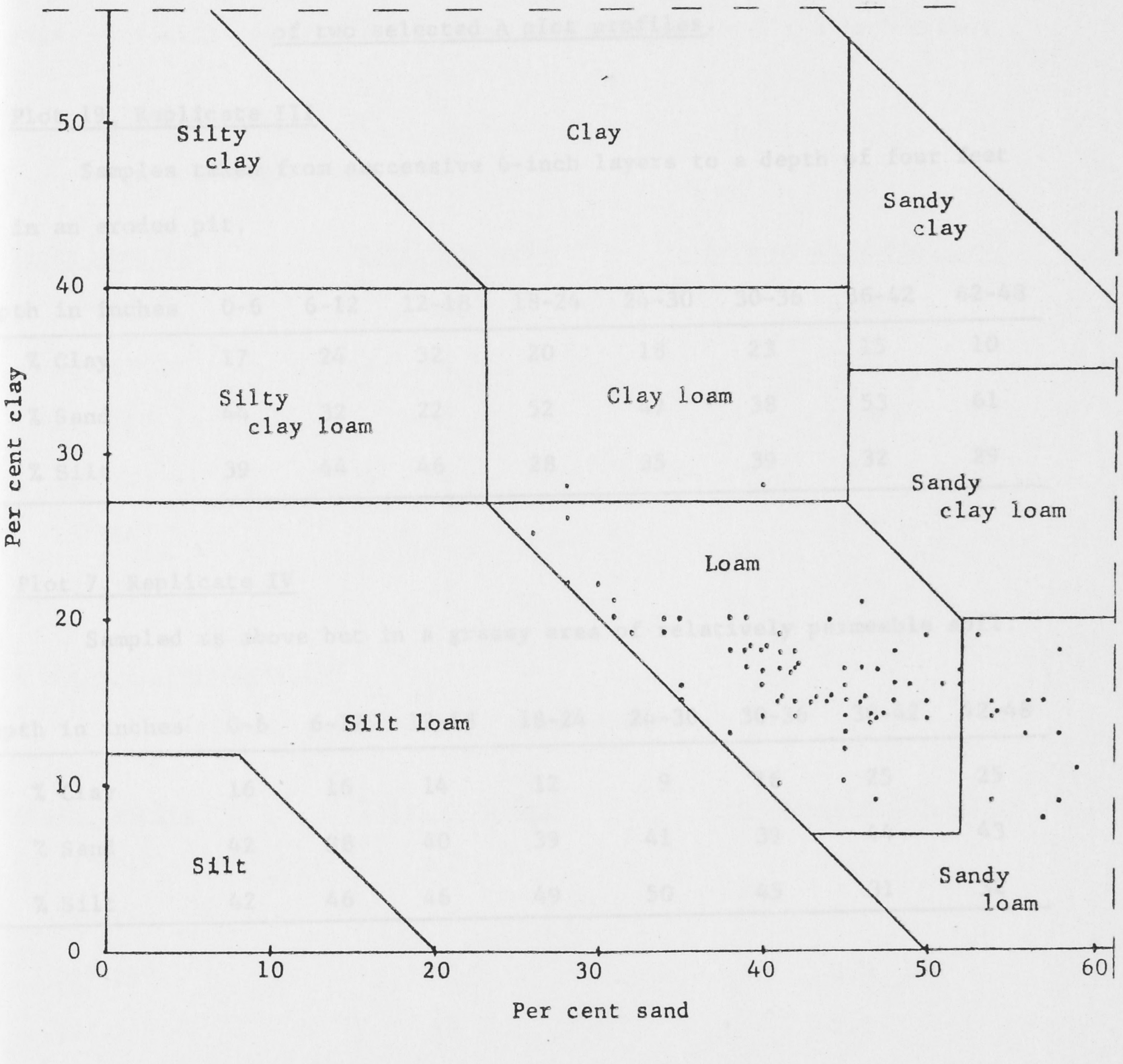
* Plots numbered west to east in each replicate.

Mechanical analyses (continued)

	Replicate III			Replicate IV		
Plot	Sand	Silt	Clay	Sand	Silt	Clay
1	38	42	20	32	49	19
2	26	49	25	31	49	20
3	28	50	22	28	44	28
4	34	47	19	28	46	26
5	35	49	16	35	45	20
6	35	50	15	38	44	18
7	44	41	15	43	42	15
8	44	41	15	45	42	13
9	42	44	14	45	45	10
10	41	44	15	47	44	9
11	39	44	17	40	32	28
12	40	44	16	31	48	21
13	42	43	15	30	48	22
14	43	42	15	34	46	20
15	42	41	17	41	44	15
16	39	41	20	45	41	14
17	42	41	17	40	42	18
18	40	43	17	41	41	18
19	45	39	16	47	39	14
20	46	39	15	45	43	12
21	46	37	17	47	39	14

Mechanical Analyses

plotted on portion of texture triangle



Note - Majority of samples fall in Loam category, with a few Sandy loams. Several samples border on Silt loam classification.

Mechanical analysis
of two selected A plot profiles.

I Plot 19, Replicate III

Samples taken from successive 6-inch layers to a depth of four feet in an eroded pit.

Depth in inches	0-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48
% Clay	17	24	32	20	18	23	15	10
% Sand	44	32	22	52	47	38	53	61
% Silt	39	44	46	28	35	39	32	29

II Plot 7, Replicate IV

Sampled as above but in a grassy area of relatively permeable soil.

Depth in inches	0-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48
% Clay	16	16	14	12	9	16	25	25
% Sand	42	38	40	39	41	39	44	43
% Silt	42	46	46	49	50	45	31	32

Porosity and permeability of A plot soils

Uhland soil core data from single profiles referred to on preceding page. Porosity and permeability both measured on the 3 x 3 inch cores.

I Plot 19, Replicate III

An eroded pit profile

Depth sampled	Total porosity	Permeability (in./hr.)
5"-8"	46%	0.33
10"-13"	41	0.05
14"-17"	42	0.00
18"-21"	39	"
23"-26"	39	"
29"-32"	37	"

II Plot 7, Replicate IV

A relatively permeable soil with grass cover.

Depth sampled	Total porosity	Permeability (in./hr.)
11"-14"	51%	9.1
16"-19"	47	4.2
22"-25"	50	2.6
26"-29"	50	1.2
31"-34"	44	0.6
36"-39"	43	0.2

Hydraulic conductivity of Hemaruka and Halladay soils

These data were reported by Krogman and Milne (Can. J. Soil Sci. 41: 188-195. 1961) on samples taken from or near the plots. The measurements were made of disturbed samples of irrigated profiles of both soil series and also on unirrigated samples of Hemaruka. Statistical analyses were run and the standard deviations are included in the table below.

Hydraulic conductivity (inches per hour)

Depth (feet)	Non-irrigated Hemaruka		Irrigated Hemaruka		Irrigated Halladay	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
0-0.5	3.40	0.81	0.60	0.15	1.80	0.68
0.5-1	0.05	0.04	0.36	0.30	1.33	0.48
1-2	0.16	0.09	0.04	0.01	0.56	0.12
2-3	0.22	0.14	0.06	0.05	0.32	0.14
3-4	0.05	0.04	0.01	0.00	0.11	0.06
4-5	0.13	0.06	0.03	0.00	0.19	0.09
5-6	0.18	0.10	0.06	0.02	0.11	0.06
6-15	0.04	-	0.06	-	0.08	-

Aggregate analysis of A plots, 1953

Mean weight diameters (mm.) as determined by a wet-sieving procedure.

Samples air-dried then wetted under vacuum.

Rotation	Treatments	Replicates I	II	III	IV
A	S	.27	.13	.23	.12
	K	.35	.40	.42	.27
	G	.23	.22	.25	.22
	M	.20	.20	.24	.23
	DC	.24	.20	.22	.26
	IC	.22	.15	.25	.16
	Dry	.13	.24	.23	.13
B	S	.24	.23	.21	.20
	K	.30	.45	.41	.40
	G	.23	.21	.26	.22
	M	.16	.20	.21	.29
	DC	.23	.18	.24	.27
	IC	.17	.27	.27	.20
	Dry	.23	.22	.27	.22
C	S	.21	.23	.29	.21
	K	.35	.41	.38	.43
	G	.24	.19	.24	.28
	M	.24	.24	.23	.19
	DC	.29	.18	.22	.22
	IC	.30	.24	.23	.20
	Dry	.19	.22	.22	.20

Treatment averages

S	.24
K	.38
G	.23
M	.22
DC	.23
IC	.22
Dry	.21

Aggregate analysis of A plots, 1959

Mean weight diameters (mm.) as determined by a wet-sieving procedure.

Samples collected in the field in moist state and kept moist until analysis performed.

Rotation	Treatments	Replicates I	II	III	IV
A	S	1.20	1.15	1.10	1.62
	K	.66	.96	1.48	1.65
	G	.96	1.18	1.12	1.29
	M	1.23	.75	1.38	1.16
	DC	.73	.89	1.48	1.64
	IC	.89	1.29	1.13	.94
	Dry	.69	.54	1.19	.92
B	S	1.22	.82	1.27	1.03
	K	1.08	.88	1.52	1.73
	G	1.02	.79	.93	.69
	M	1.44	1.00	.90	1.13
	DC	1.14	1.36	1.19	.82
	IC	.46	1.20	.92	1.67
	Dry	.95	.75	.87	.92
C	S	.91	.91	.99	.91
	K	1.14	.88	.72	1.16
	G	1.00	.98	.85	1.39
	M	1.20	.90	1.25	.95
	DC	.98	.91	.93	.69
	IC	1.17	.78	.93	.65
	Dry	.98	.77	.58	.70

Treatment averages

S	1.09
K	1.16
G	1.02
M	1.11
DC	1.06
IC	1.00
Dry	0.82

Penetrometer Studies

Since the hardpan in the problem soils under study was the distinctive feature that we wished to observe and study it was felt necessary to attempt some method of assessing any beneficial effects the treatments might be bringing about. A penetrometer seemed to be a promising device, that is an instrument by means of which the pressure or force needed to force a probe into the soil could be measured. Hardpans are readily detected by such an instrument. A great disadvantage is the pronounced effect of soil moisture content on pressure readings, the tendency being to find low values in moist soils and high values in dry ones.

Dr. A. L. Mathieu, in connection with his M.Sc. program, designed and had built a recording type of penetrometer which made it possible to take penetrometer readings rapidly.* This was essential in order to have sufficient replications of measurement to overcome normal variability in soils. It was particularly important here where the soil was so variable to begin with.

Details of the 1953 penetrometer studies are given in Mathieu's M.Sc. thesis. His charts of isoprobe depths for A plots are reproduced on page E 11. The charts show, for each Replicate or Range, the following details:

(1) The elevation of the surface of each plot at three points (locations a, b, and c) relative to the highest point in the plot area (Range 1, border between plots 15 and 16.

(2) The treatments and plot numbers.

(3) The depth of June isoprobes (solid line) and September isoprobes (dotted line). Dr. Mathieu defined isoprobe as the depth at which the penetrometer tension spring was compressed six inches by resistance of the soil to further movement of the probe. The probe was forced into the soil three times at each location and the average depth plotted as the isoprobe.

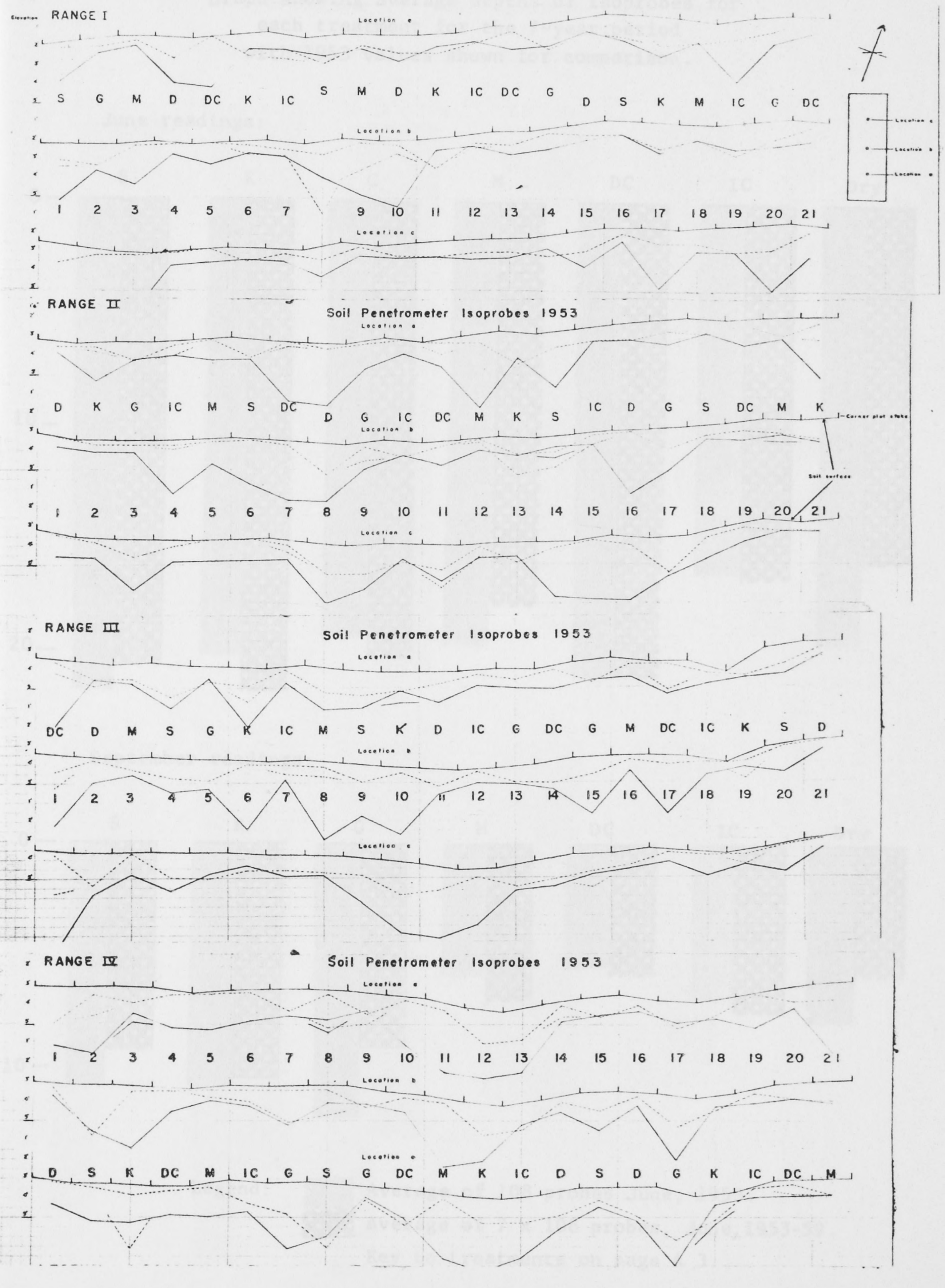
The data for 1953 are compared with the 7-year averages for 1953-1959 on page E 12. On pages E 13 and E 14 data for the B plots for the years 1954-1959, June readings only, are summarized.

* For a description of the instrument and its use see "A self-recording soil penetrometer" by A. L. Mathieu and J. A. Toogood in Vol. 38, No. 2 of Can. J. Soil Sci., 1958.

Penetrometer data for A plots, 1953

(From M.Sc. thesis of A. L. Mathieu, 1954. See page E 10 for explanation of diagrams.)

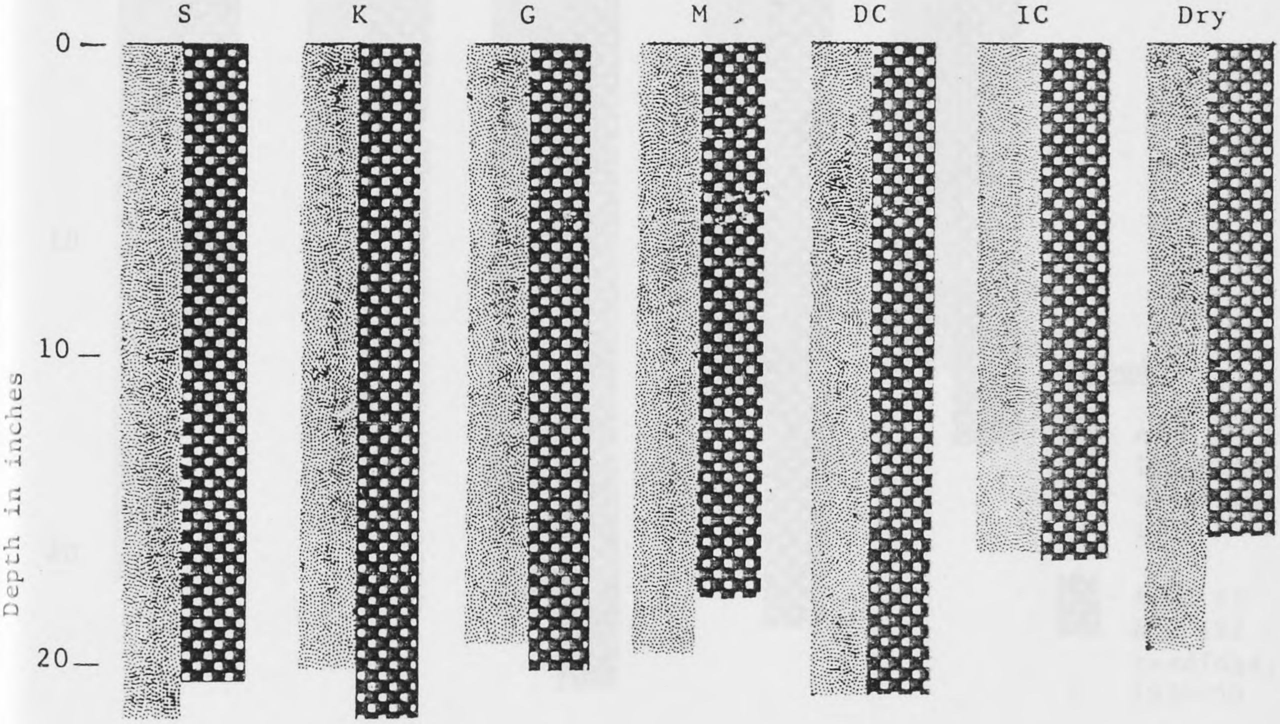
See page E 10



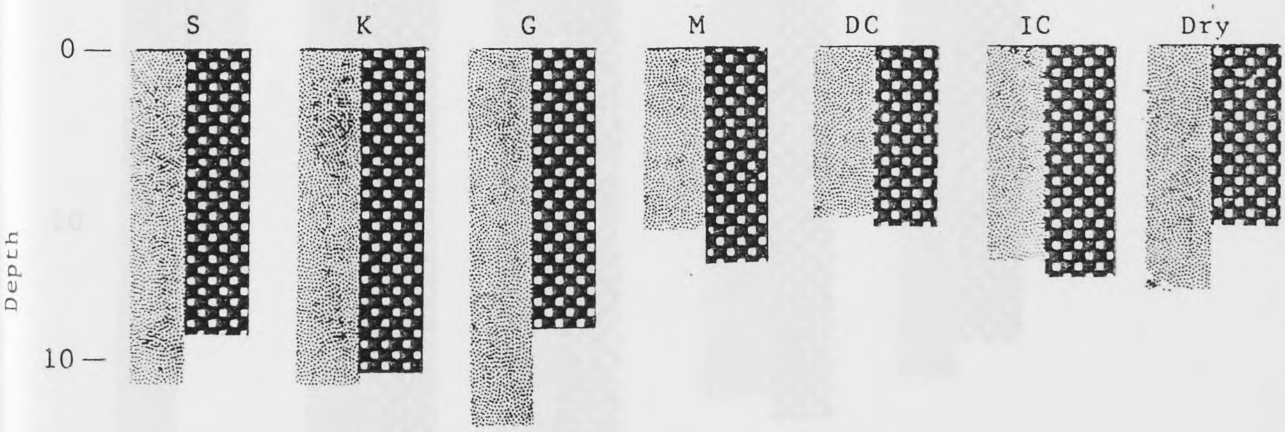
Penetrometer data for A plots, 1953-1959

Graph showing average depths of isoprobes for each treatment for the 7-year period with 1953 values shown for comparison.

June readings:



September readings:



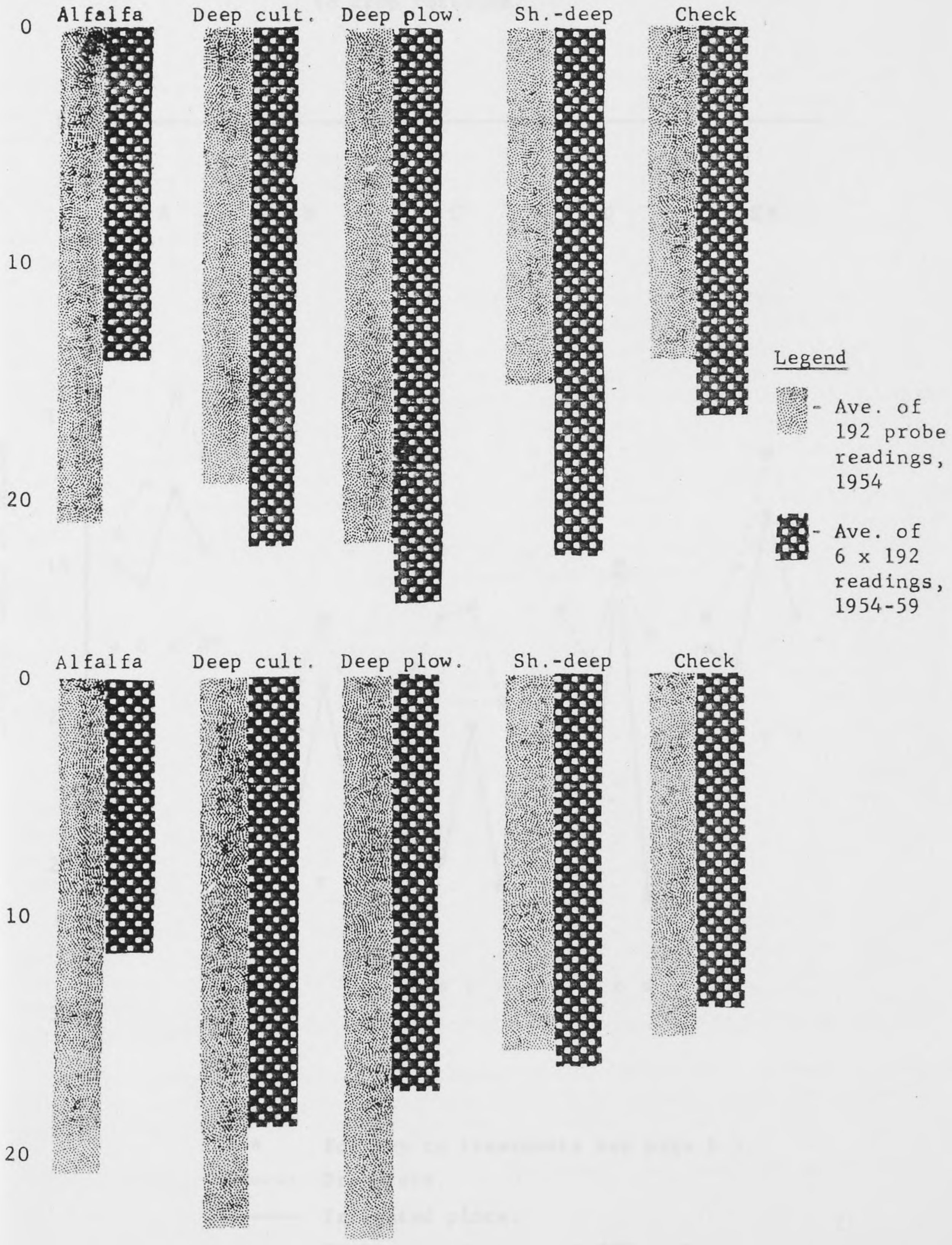
Legend: Average of 108 probes June, 1953.
Average of 7 x 108 probes, June, 1953-59.
Key to treatments on page A 3.

Penetrometer data for B plots 1954-59

Graph showing average depth of June isoprobes

for irrigation and dry plots for the 6-year period

with 1954 values shown for comparison

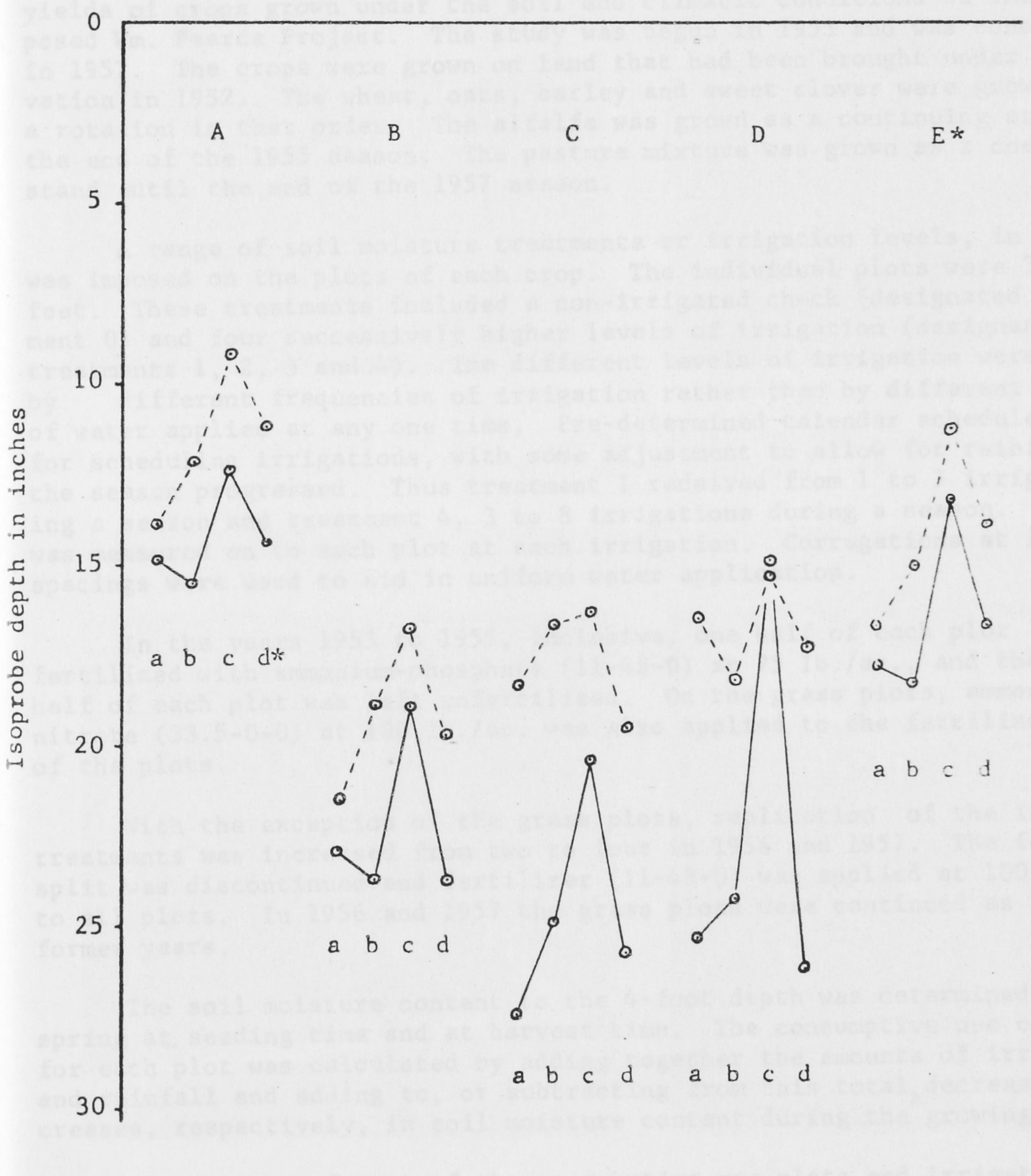


Penetrometer data for B plots

Averages of 1954-59 June isoprobe readings

for irrigation and dry plots according

to crop rotation.



Legend:

* For key to treatments see page B 3.

------ Dry plots.

——— Irrigated plots.

⊙ Each point average of 288 probes.

APPENDIX F

Studies on Consumptive Use of Water

- K. K. Krogman

Wheat, oats, barley, sweet clover, alfalfa and pasture mixture* were included in a study to determine the consumptive use of water at maximum yields of crops grown under the soil and climatic conditions of the proposed Wm. Pearce Project. The study was begun in 1953 and was concluded in 1957. The crops were grown on land that had been brought under cultivation in 1952. The wheat, oats, barley and sweet clover were grown in a rotation in that order. The alfalfa was grown as a continuing stand until the end of the 1955 season. The pasture mixture was grown as a continuing stand until the end of the 1957 season.

A range of soil moisture treatments or irrigation levels, in duplicate, was imposed on the plots of each crop. The individual plots were 31 x 55 feet. These treatments included a non-irrigated check (designated as treatment 0) and four successively higher levels of irrigation (designated as treatments 1, 2, 3 and 4). The different levels of irrigation were achieved by different frequencies of irrigation rather than by different amounts of water applied at any one time. Pre-determined calendar schedules were used for scheduling irrigations, with some adjustment to allow for rainfall as the season progressed. Thus treatment 1 received from 1 to 3 irrigations during a season and treatment 4, 3 to 8 irrigations during a season. The water was measured on to each plot at each irrigation. Corrugations at 18-inch spacings were used to aid in uniform water application.

In the years 1953 to 1955, inclusive, one half of each plot was fertilized with ammonium-phosphate (11-48-0) at 75 lb./ac., and the other half of each plot was left unfertilized. On the grass plots, ammonium-nitrate (33.5-0-0) at 100 lb./ac. was also applied to the fertilized halves of the plots.

With the exception of the grass plots, replication of the irrigation treatments was increased from two to four in 1956 and 1957. The fertilizer split was discontinued and fertilizer (11-48-0) was applied at 100 lb./ac. to all plots. In 1956 and 1957 the grass plots were continued as in the former years.

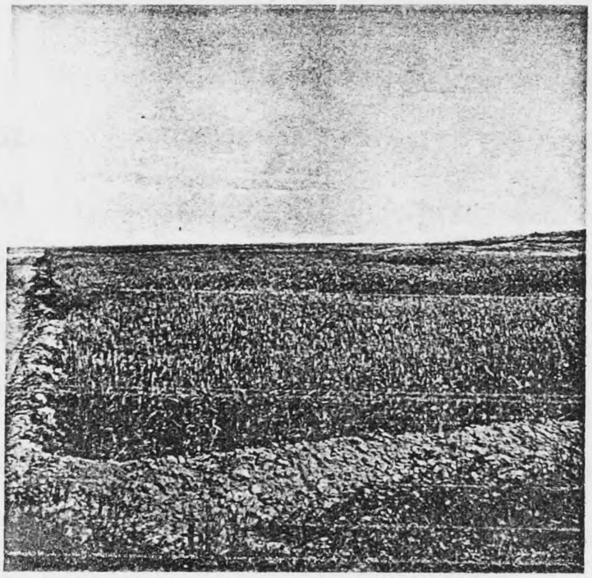
The soil moisture content to the 4-foot depth was determined in the spring at seeding time and at harvest time. The consumptive use of water for each plot was calculated by adding together the amounts of irrigation and rainfall and adding to, or subtracting from this total, decreases or increases, respectively, in soil moisture content during the growing season.

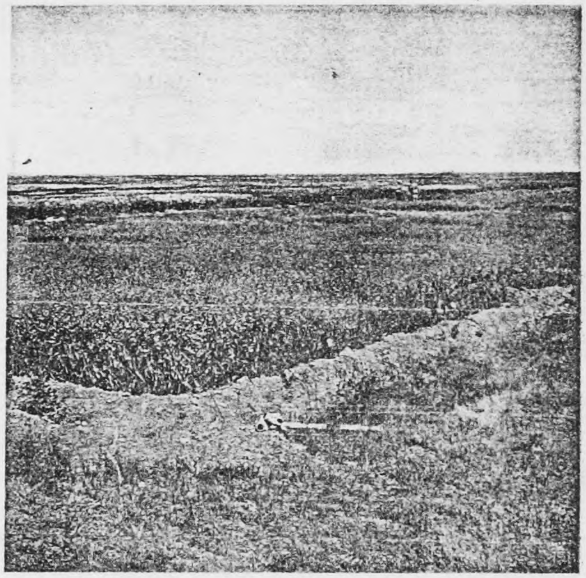
Photographs of some of the consumptive use plots and irrigation techniques are shown on page F 2. Data on precipitation and evaporation are given on page F 3 and yields and consumptive use on pages F 4 - F 6.

* Brome grass, Orchard grass, Creeping Red Fescue and White Dutch Clover.

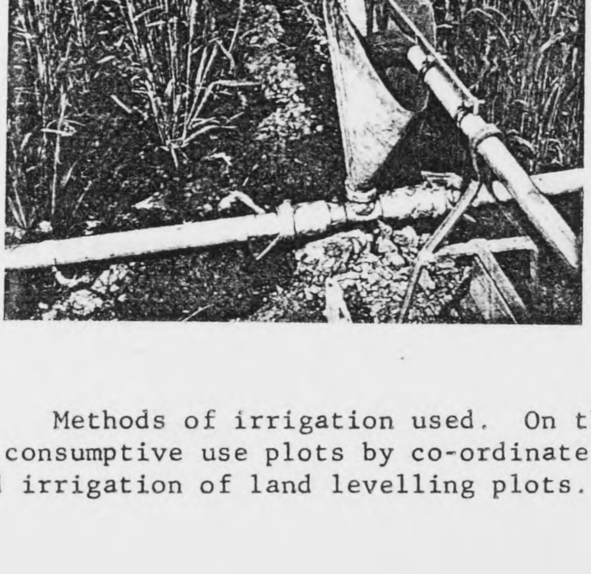
Photographs of Lethbridge Research

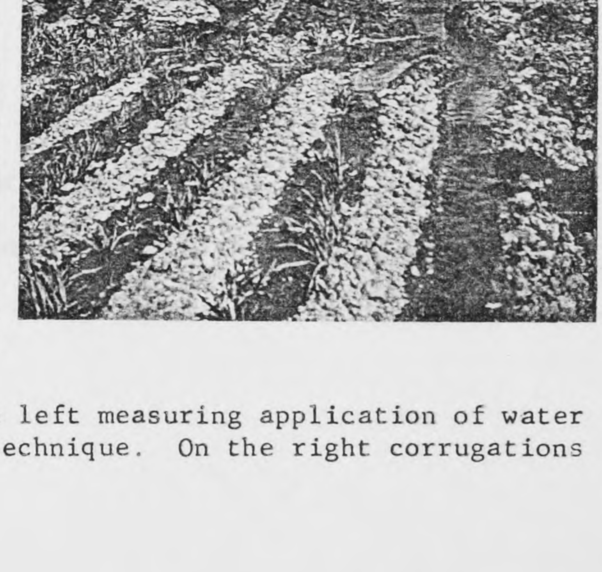
Station Experiments





Consumptive use plots showing wheat and oat crops.
Note variability in stands of the two crops.





Methods of irrigation used. On the left measuring application of water to consumptive use plots by co-ordinate technique. On the right corrugations and irrigation of land levelling plots.

Precipitation at the

Youngstown plots, 1952 - 1957

	May	June	July	Aug.	Sept.	Total
1952	0.79	4.17	0.74	1.31	0.72	7.73
1953	1.43	4.62	1.36	3.40	0.96	11.77
1954	2.20	2.25	1.67	8.97	2.38	17.47
1955	3.11	1.26	1.34	0.37	2.10	8.08
1956	0.96	5.05	3.64	3.23	0.49	13.37
1957	0.27	1.23	0.67	2.87	0.42	5.46
	Note - Compare with 18-year average figures for Hanna					
	1.72	2.90	2.56	1.46	0.90	9.54

Total evaporation from free water surface*

(during the growing season)

1952 - 25.16 inches

1953 - 23.83

1954 - 23.92

1955 - 26.62

1956 - 27.96

1957 - 30.37

* Evaporation was measured at the Youngstown Plots using a pan 4 feet in diameter, 2 feet deep, and buried in the soil with 2 inches of the rim projecting above the earth.

Yield and Consumptive Use - Wheat

Yield - bu./ac.

Use - inches

Treatment		1953		1954		1955		1956		1957	
Irrig.	Fert.*	Yield	Use	Yield	Use	Yield	Use	Yield	Use	Yield	Use
0	0			10.4	9.0	22.8	7.6	-	-	-	-
	x	No		9.6	10.8	23.7	8.8	33.6	14.3	-**	4.8
1	0	wheat		19.8	16.0	46.4	14.4	-	-	-	-
	x			19.0	16.9	44.4	11.0	38.8	15.7	-	11.0
		seeded									
2	0			26.6	15.8	52.4	14.2	-	-	-	-
	x	in 1953		27.6	17.8	50.1	15.6	34.4	17.7	-	14.4
3	0			29.8	13.8	49.4	16.1	-	-	-	-
	x			26.0	15.4	44.8	13.8	41.2	18.9	-	16.9
4	0			25.5	18.2	50.5	14.7	-	-	-	-
	x			26.2	17.2	53.2	15.5	41.5	19.5	-	17.0
		Yield and Consumptive Use - Barley									
0	0	16.4	7.6	9.9	13.8	22.0	8.0	-	-	-	-
	x	24.0	8.3	15.0	10.6	30.2	6.8	51.6	12.4	-**	3.8
1	0	29.6	8.9	22.6	16.2	42.3	14.2	-	-	-	-
	x	30.8	10.0	31.8	15.7	43.5	13.7	49.8	14.0	-	9.4
2	0	40.0	11.2	11.1	15.7	53.5	12.9	-	-	-	-
	x	39.3	11.7	34.8	17.8	43.0	10.3	54.8	16.1	-	12.0
3	0	37.9	12.0	10.8	15.3	31.7	11.6	-	-	-	-
	x	39.3	11.9	23.0	15.6	34.0	12.4	59.2	17.0	-	13.7
4	0	39.6	13.8	37.8	15.0	32.2	18.5	-	-	-	-
	x	54.7	14.7	42.5	16.0	41.7	18.6	64.3	18.8	-	16.6

* 0 - Unfertilized
x - Fertilized
** - Hailed

Yield and Consumptive Use - Oats

Yield - bu./ac.

Use - inches

Treatment		1953		1954		1955		1956		1957	
Irrig.	Fert.*	Yield	Use	Yield	Use	Yield	Use	Yield	Use	Yield	Use
0	0	27.0	8.3	24.8	14.2	40.7	11.4	-	-	-	-
	x	6.2	8.4	28.5	12.4	47.4	9.5	94.5	14.0	-**	4.0
1	0	41.0	8.8	51.6	15.8	58.8	11.4	-	-	-	-
	x	56.2	10.2	60.6	14.4	58.1	11.0	87.2	14.3	-	10.2
2	0	29.9	11.8	54.4	16.3	57.7	12.6	-	-	-	-
	x	58.5	12.2	58.7	18.6	62.1	11.2	91.8	17.5	-	10.7
3	0	44.4	11.7	54.6	16.0	81.8	16.2	-	-	-	-
	x	73.5	11.3	70.6	20.4	69.4	16.0	84.8	17.6	-	12.4
4	0	75.3	15.6	75.7	19.6	70.7	13.0	-	-	-	-
	x	96.4	17.1	96.6	17.2	80.7	15.0	96.0	18.0	-	14.2

Yield and Consumptive Use - Sweet Clover

Yield - Tons Per Acre of Total Dry Matter

Irrig.	Fert.*	1953	1954 Yield	1954 Use	1955 Yield	1955 Use	1956 Yield	1956 Use	1957 Yield	1957 Use
0	0		0.54	-	0.45	4.8	0.58	10.9	-	-
	x	First year	0.64	-***	0.60	7.0	0.54	12.6	0.25	6.0
1	0	of	1.08	-	0.62	7.0	2.04	15.2	-	-
	x		0.91	-	0.40	6.6	1.62	14.7	0.57	11.6
		rotation.								
2	0		1.24	-	0.20	7.2	2.01	13.2	-	-
	x	No yields	1.13	-	1.06	8.6	1.31	13.6	0.79	16.1
3	0	of sw. cl.	1.26	-	0.34	6.9	2.54	16.0	-	-
	x		1.01	-	0.77	5.8	1.90	14.8	1.08	16.0
4	0		0.82	-	1.09	9.0	1.77	17.6	-	-
	x		1.07	-	1.15	9.2	2.36	17.0	0.96	17.0

* 0 - Unfertilized
  x - Fertilized
 ** - Hailed
*** - Soil samples not taken

Yields and Consumptive Use - Alfalfa

Yield - Tons Per Acre of Total Dry Matter

Use - Inches

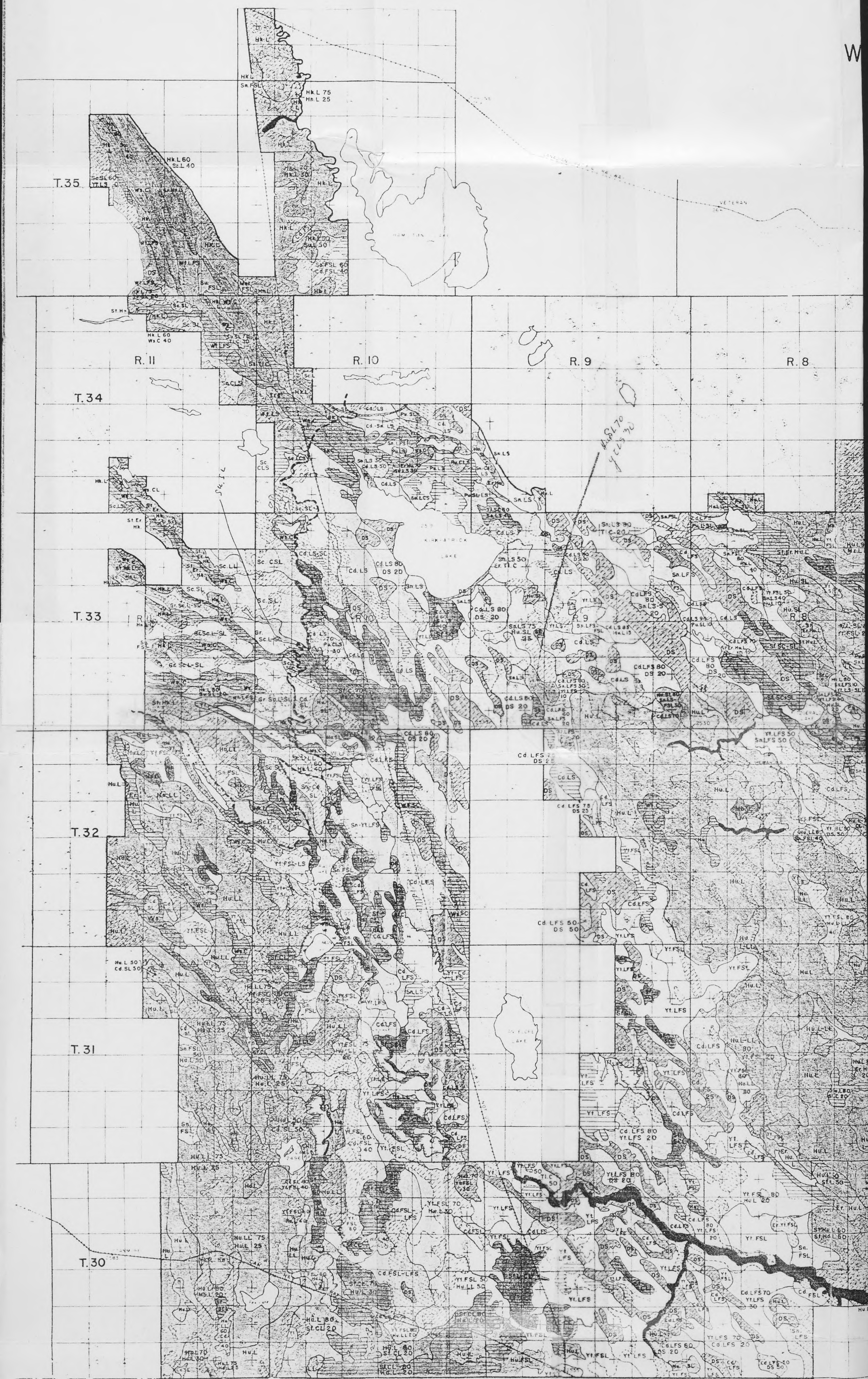
Treatment		1953		1954		1955		1956		1957	
Irrig.	Fert.*	Yield	Use	Yield	Use	Yield	Use	Yield	Use	Yield	Use
0	0	0.15	-	0.60	14.3	0.29	8.8	Samples for yield determination not taken.			
	x	0.16	-**	0.35	14.8	0.18	8.3				
1	0	0.30	-	1.58	17.2	0.88	13.1				
	x	0.33	-	0.94	18.6	0.74	13.7				
2	0	0.20	-	0.86	17.0	0.43	12.8				
	x	0.42	-	2.29	18.8	1.20	14.0				
3	0	0.48	-	2.01	17.8	2.01	18.4				
	x	0.58	-	2.24	19.5	1.79	18.6				
4	0	0.60	-	2.69	18.7	2.22	19.1				
	x	0.67	-	2.65	20.5	2.66	19.0				

Yields and Consumptive Use - Pasture Mixture

Yield - Tons Per Acre of Total Dry Matter

Irrig.	Fert.*	1953	1954 Yield	1954 Use	1955 Yield	1955 Use	1956 Yield	1956 Use	1957 Yield	1957 Use
0	0	Stand being established. No yields.	0.34	6.6	0.13	6.1	0.13	13.8	0.02	6.5
	x		0.34	7.0	0.22	7.4	0.44	15.0	0.18	6.4
1	0		0.95	8.8	0.38	7.0	0.39	16.6	0.38	13.2
	x		0.85	9.1	0.36	7.7	0.45	15.8	0.40	10.2
2	0		0.39	8.5	0.24	7.8	0.22	17.0	0.11	12.2
	x		0.48	6.0	0.23	8.1	0.60	16.6	0.47	11.1
3	0		0.63	9.0	0.32	6.4	0.48	19.6	0.16	17.4
	x		0.74	9.9	0.41	8.6	0.92	20.6	0.58	16.8
4	0		0.55	10.4	0.52	9.6	0.56	22.8	0.36	22.2
	x		0.66	9.0	0.60	8.1	1.12	22.4	0.62	20.7

* 0 - Unfertilized
x - Fertilized
** - Soil samples not taken.



T.35
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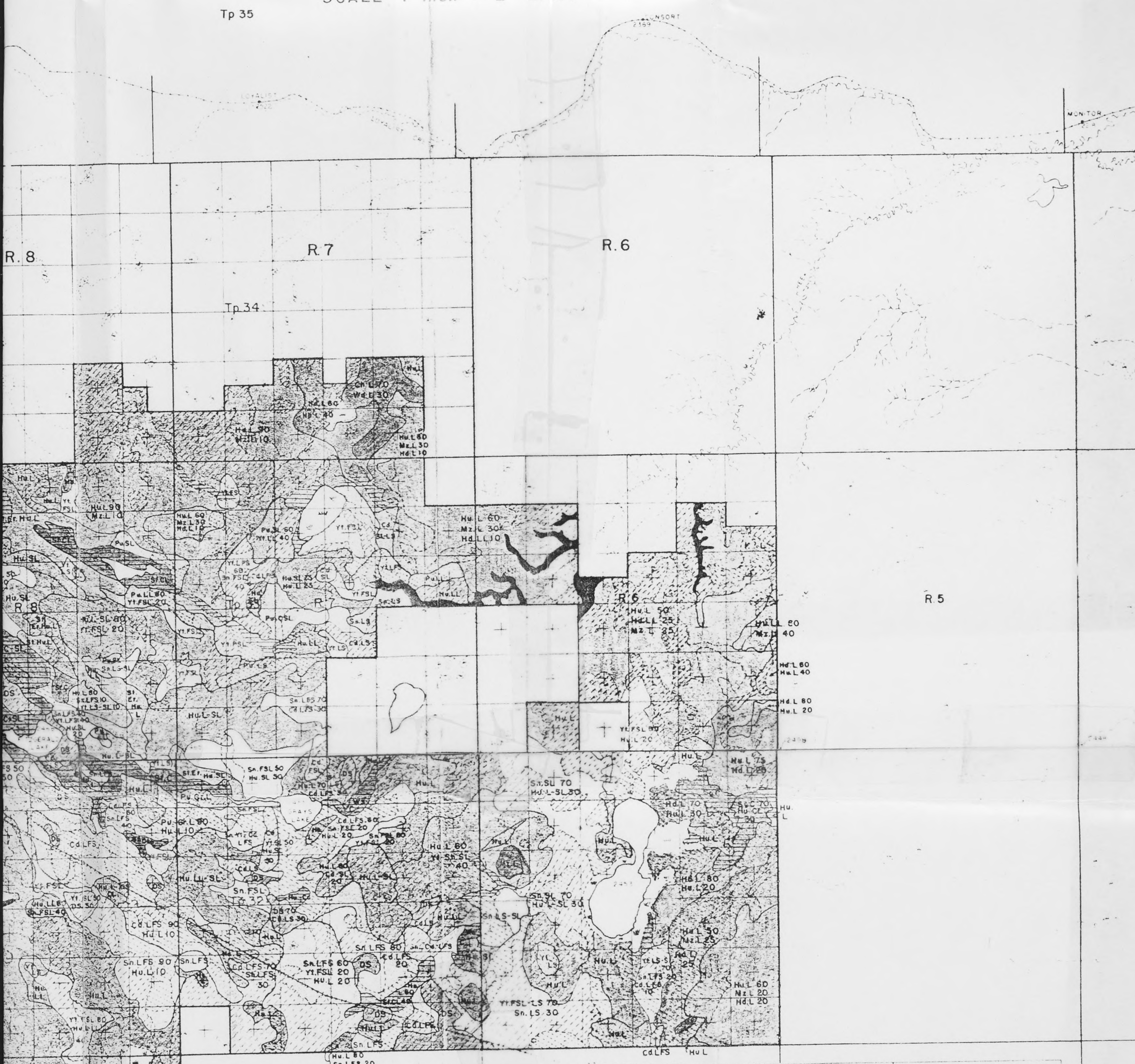
R. 11
R. 10
R. 9
R. 8
KIRKPATRICK
LAKE

WILLIAM PEARCE IRRIGATION PROJECT

NORTHERN PORTION

SOIL and TOPOGRAPHY

SCALE 1 inch = 2 miles



ORDER	GREAT GROUP	SUB-GROUP	SERIES	SYMBOL	TEXTURE	PARENT MATERIAL	
CHERNOZEMIC	BROWN	ORTHIC	Pemukan	Pu	LS, LCS, SL, CSL, LL, L	Outwash	
			Cavendish	Cd	LS, LFS, LCS	Alluvial aeolian	F-FG
			Cavendish	Cd	SL, FSL	Alluvial aeolian	
			Chin	Ch	L	Alluvial lacustrine	VG
			Maleb	[illegible]	L	Till	G
			Malez	[illegible]	L	Till	
	DARK BROWN	ORTHIC	Scollard	Sc	LS, LCS, SL, CSL, LL, L	Outwash	P-F
			Wainwright	Wt	LS, LFS	Alluvial aeolian	FG
			Metiskow	[illegible]	SL, FSL	Alluvial aeolian	FG
			Hughendon	[illegible]	L	Till	
SOLONETZIC	SOLOD	BROWN	Holliday	[illegible]	LL, L	Till	F-FG
	SOLODIZED SOLONETZ	BROWN	Sunnynook	Sn	LS, LCS, LFS, SL, FSL	Alluvial aeolian/till	P-F
			Youngstown	Yt	LS, LFS, SL, FSL, LL	Alluvial aeolian	P-FG
			Wardlow	Wd	L	Alluvial lacustrine	P-F
			Hemaruka	Hu	SL, LL, L, CL	Till	P
		DARK BROWN	Sullivan Lake	Su	SL, FSL, L	Alluvial aeolian	P
			Halkirk	[illegible]	L	Till	P
	SOLONETZ	BROWN and	Stirling	Sg	C	Lacustrine	
		DARK BROWN	Torlea	[illegible]	SC, C	Residual	P
		DARK BROWN	Watts	Ws	CL, SC, C	Lacustrine	
REGOSOLIC	REGOSOL	ORTHIC	Dune Sand	DS		Aeolian	
		SALINE	Scottfield	St	SL, L, SCL, CL, C	Alluvial & lacustrine	P

105,600

8,000

202,900

22,500

35,900

- T1 Gently Sloping
- T2 Gently Undulating
- T3 Gently Undulating - Undulating

} irrigable topographic classes corresponding fairly closely to T1, T2, & T3 in B.R. Project

- Depressional
- Roughly Undulating to Rolling topography generally too irregular to irrigate

SOIL PREFIXES

Er - Eroded - most of A horizon removed

St - Stony - surface stones exceed S3

Gr - Gravelly

Rough broken land adjacent to stream courses

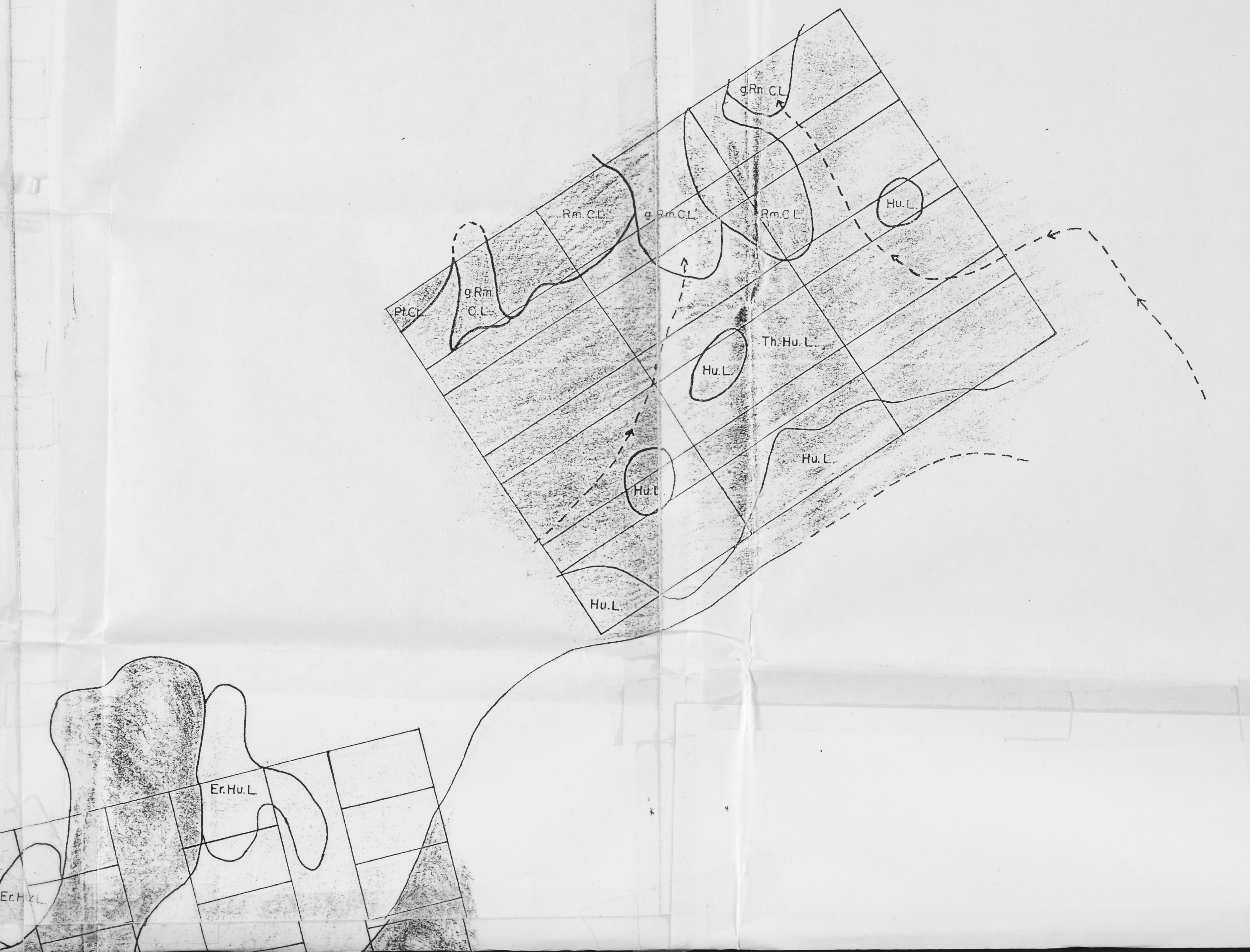
Slough

WILLIAM PEARCE IRRIGATION PROJECT
YOUNGSTOWN PLOTS

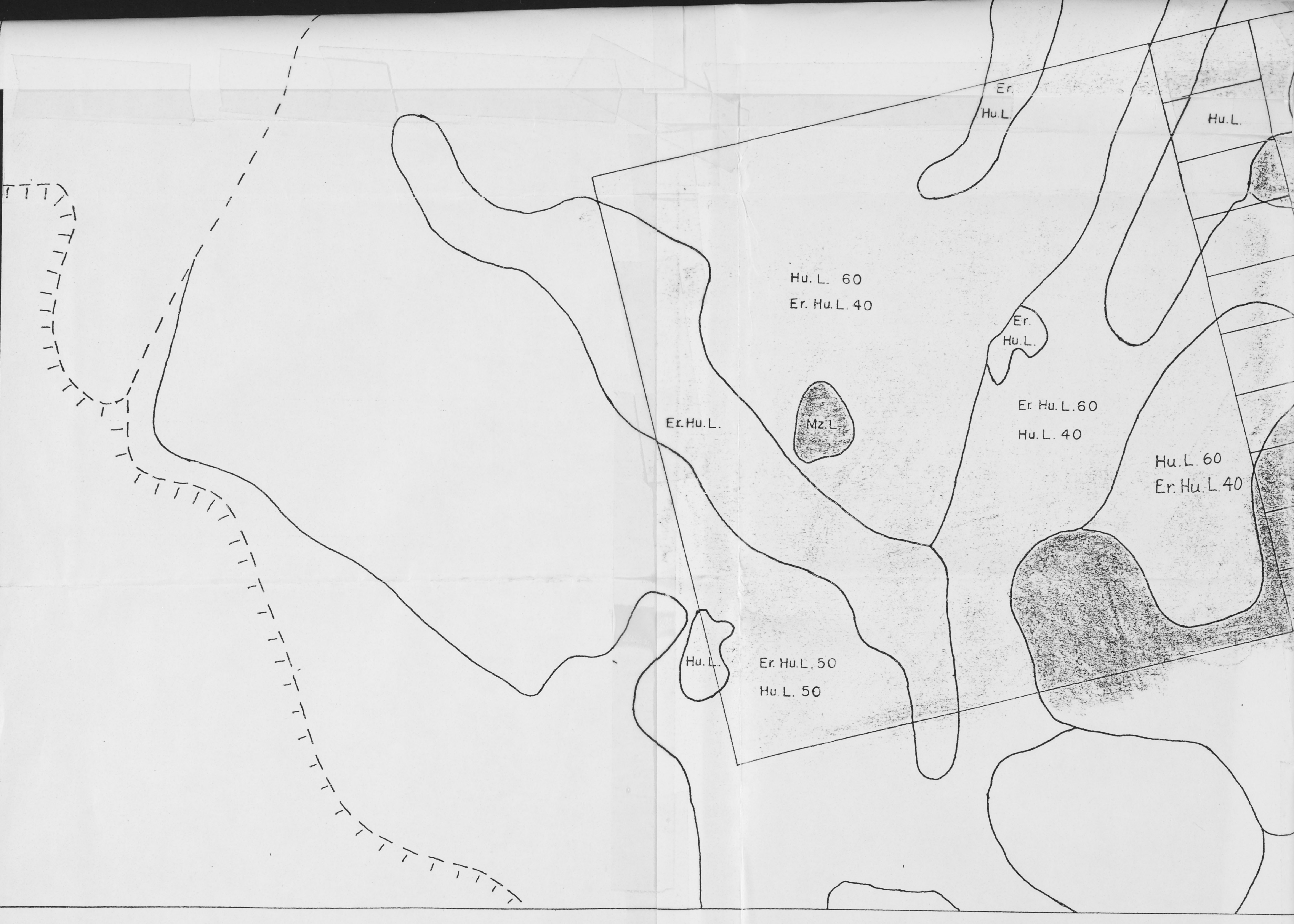
DETAILED SOIL SURVEY

SCALE: 1 inch = 50 feet

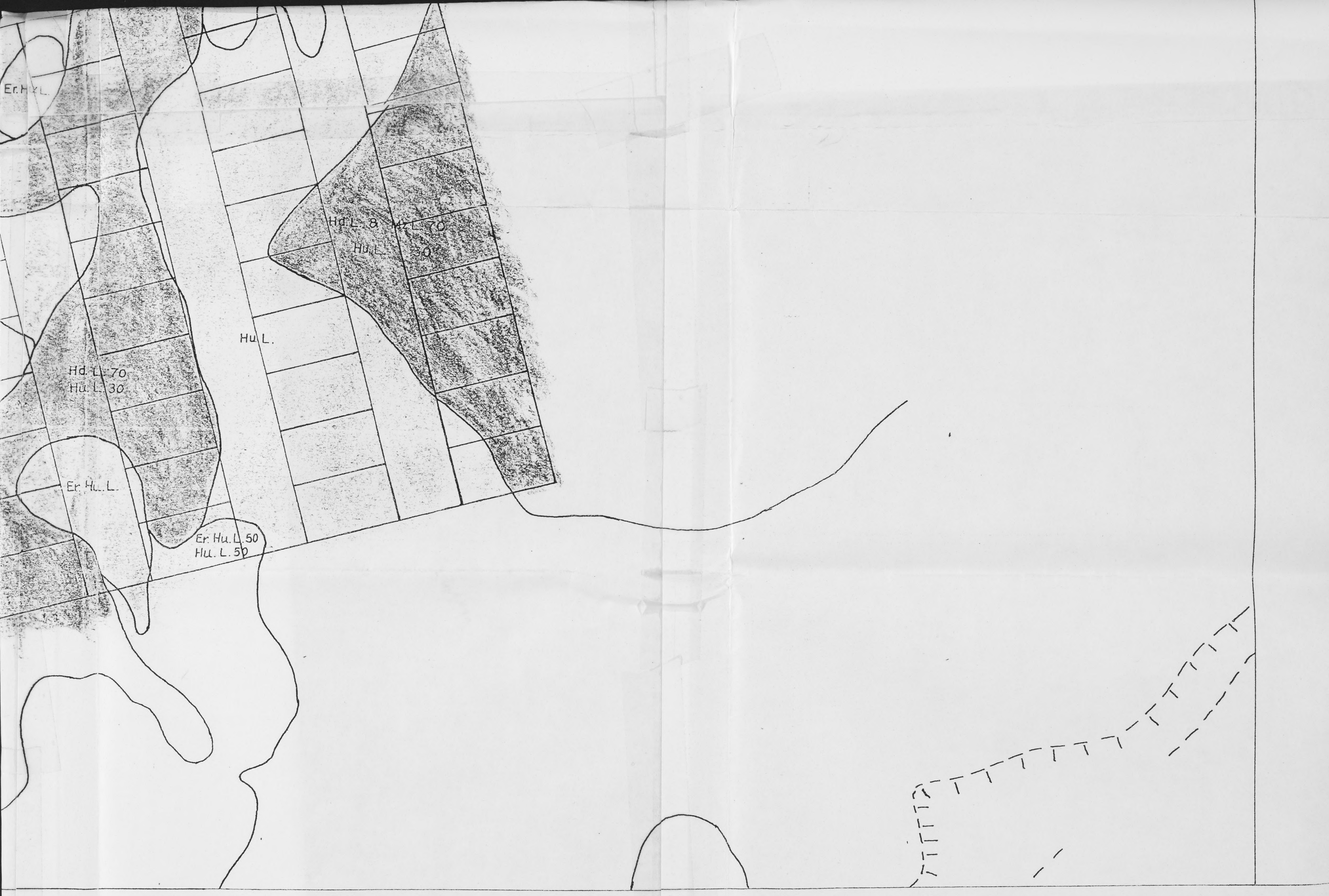
ORDER	GREAT GROUP	SUB GROUP	SERIES	SYMBOL	TEXTURE	PARENT MATERIAL
CHERNOZEMIC	BROWN	ORTHIC	Malez	Mz.	L.	Till
SOLONETZIC	BROWN	SOLOD	Rosemary	Rm.	C.L.	Lacustrine
			gleyed Rm.	g. Rm.	C.L.	" ; mottling throughout profile
			Halliday	Hd.	L.	Till
		SOLODIZED SOLONETZ	Patricia	Pt.	C.L.	Lacustrine
			Hemaruka	Hu.	L.	Till ; over 4" of A horizon
			Thin Hu.	Th.Hu.	L.	" ; 2"–4" " " ".
			Eroded Hu.	Er. Hu.	L.	" ; area has 75% of A horizon removed



g.Rm.C.L.
Rm.C.L.
g.Rm.C.L.
Rm.C.L.
Hu.L.
g.Rm.
C.L.
Pt.C.L.
Th.Hu.L.
Hu.L.
Hu.L.
Hu.L.
Hu.L.
Er.Hu.L.



Er.
Hu.L.
Hu.L.
Hu.L. 60
Er. Hu.L. 40
Er.
Hu.L.
Er. Hu.L. 60
Hu.L. 40
Mz.L.
Er.Hu.L.
Hu.L. 60
Er. Hu.L. 40
Hu.L.
Er. Hu.L. 50
Hu.L. 50



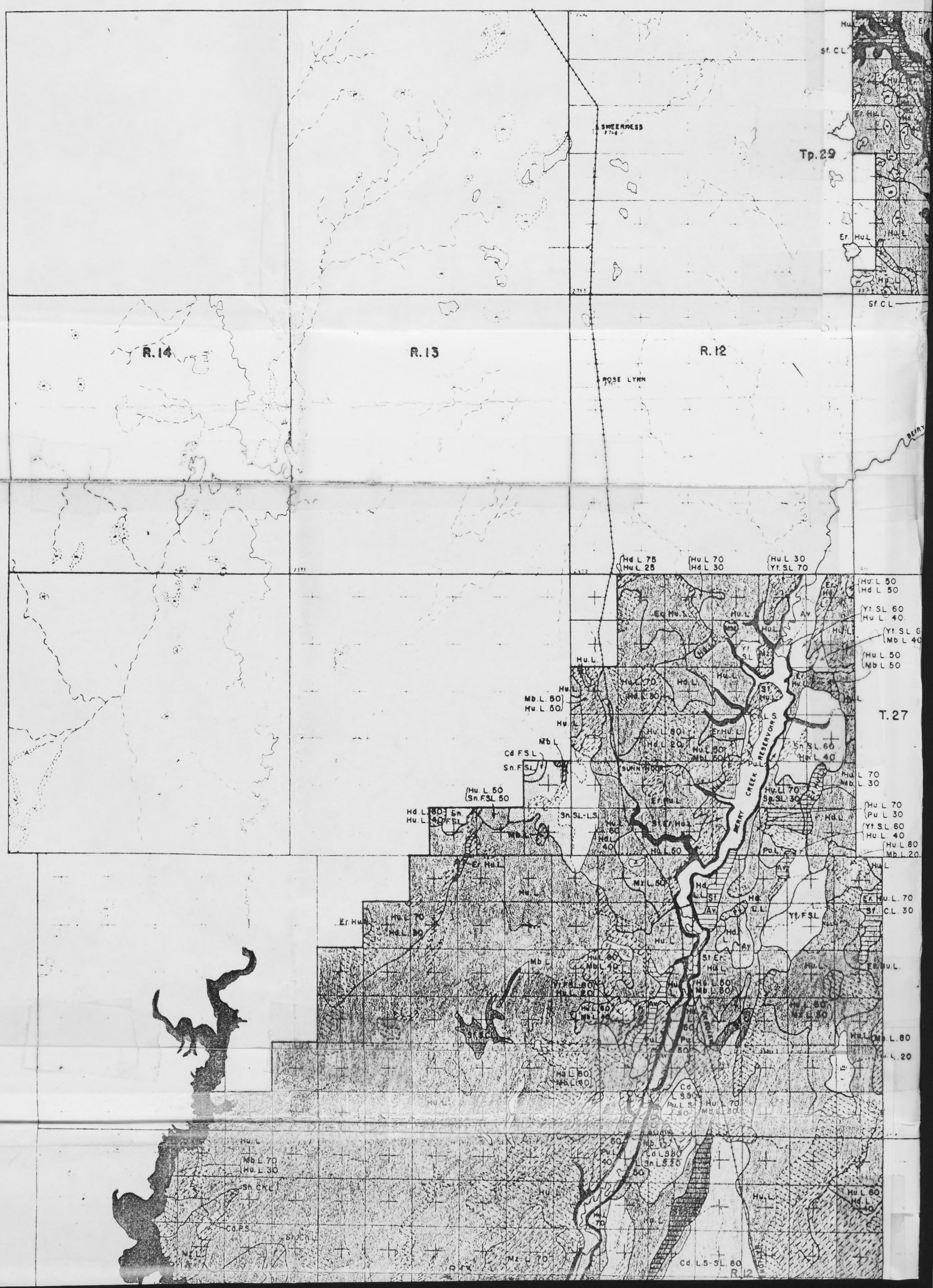
Hd.L. & Mz.L. 70
Hu.L. 30
Hu.L.
Hd.L. 70
Hu.L. 30
Er. Hu.L.
Er. Hu.L. 50
Hu.L. 50

WILLIAM PEARCE IRRI

SOUTHERN PO

SOIL and TO

SCALE 1 inch =

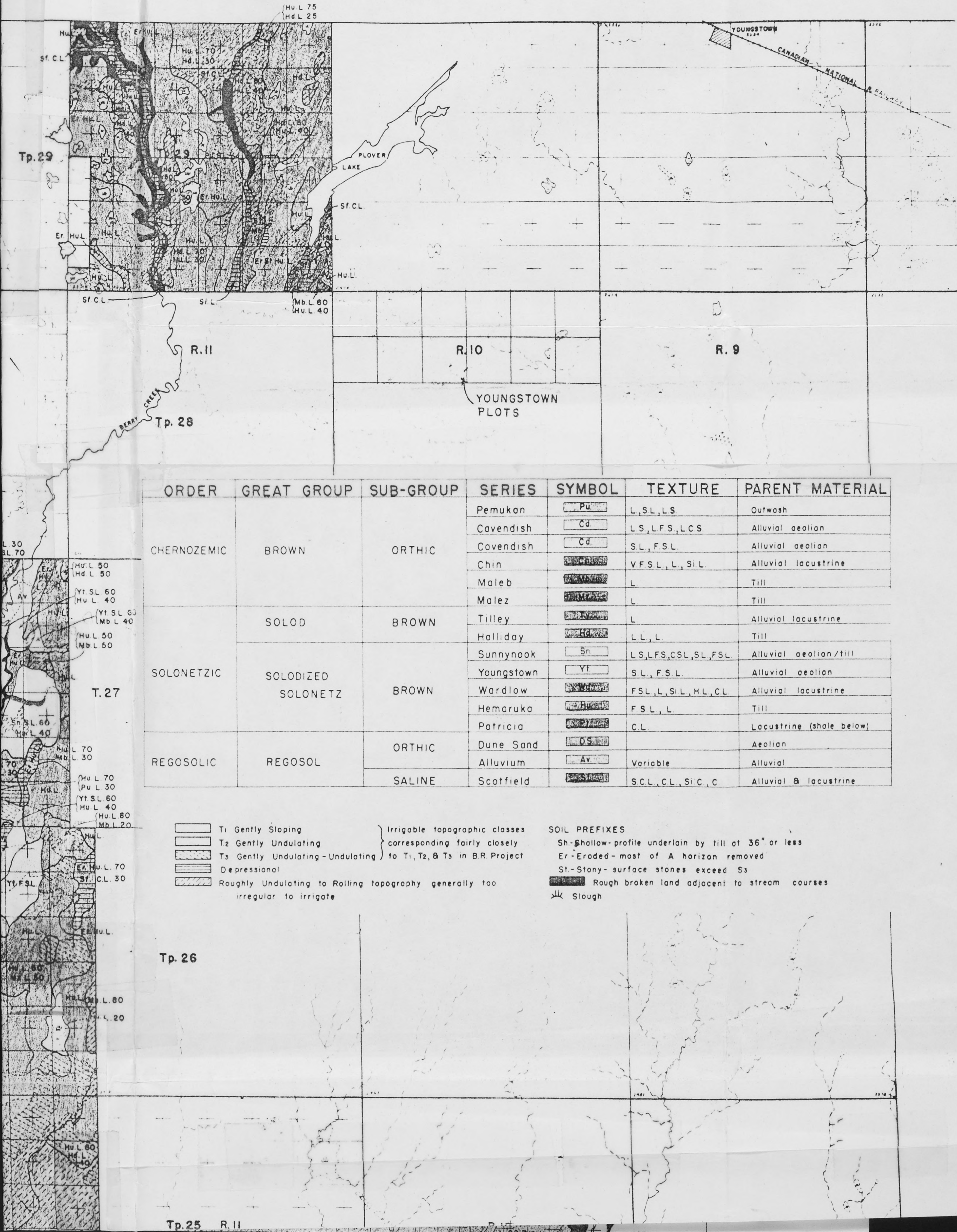


RCE IRRGATION PROJECT

OUTHERN PORTION

and TOPOGRAPHY

SCALE 1 inch : 2 miles



ORDER	GREAT GROUP	SUB-GROUP	SERIES	SYMBOL	TEXTURE	PARENT MATERIAL
CHERNOZEMIC	BROWN	ORTHIC	Pemukan	Pu	L, SL, LS	Outwash
			Cavendish	Cd	LS, LFS, LCS	Alluvial aeolian
			Cavendish	Cd	SL, FSL	Alluvial aeolian
			Chin	Ch	VFSL, L, SiL	Alluvial lacustrine
			Maleb	Mb	L	Till
			Malez	Mz	L	Till
SOLONETZIC	SOLOD	BROWN	Tilley	Ty	L	Alluvial lacustrine
			Halliday	Hd	LL, L	Till
	SOLODIZED SOLONETZ	BROWN	Sunnynook	Sn	LS, LFS, CSL, SL, FSL	Alluvial aeolian/till
			Youngstown	Yt	SL, FSL	Alluvial aeolian
			Wardlow	Wd	FSL, L, SiL, HL, CL	Alluvial lacustrine
			Hemaruka	Hu	FSL, L	Till
			Patricia	Pa	CL	Lacustrine (shale below)
REGOSOLIC	REGOSOL	ORTHIC	Dune Sand	DS		Aeolian
			Alluvium	Av	Variable	Alluvial
		SALINE	Scotfield	Sf	SCL, CL, SiC, C	Alluvial & lacustrine

T1 Gently Sloping
T2 Gently Undulating
T3 Gently Undulating - Undulating

Irrigable topographic classes corresponding fairly closely to T1, T2, & T3 in B.R. Project

Depressional

Roughly Undulating to Rolling topography generally too irregular to irrigate

SOIL PREFIXES

Sh - Shallow - profile underlain by till at 36" or less

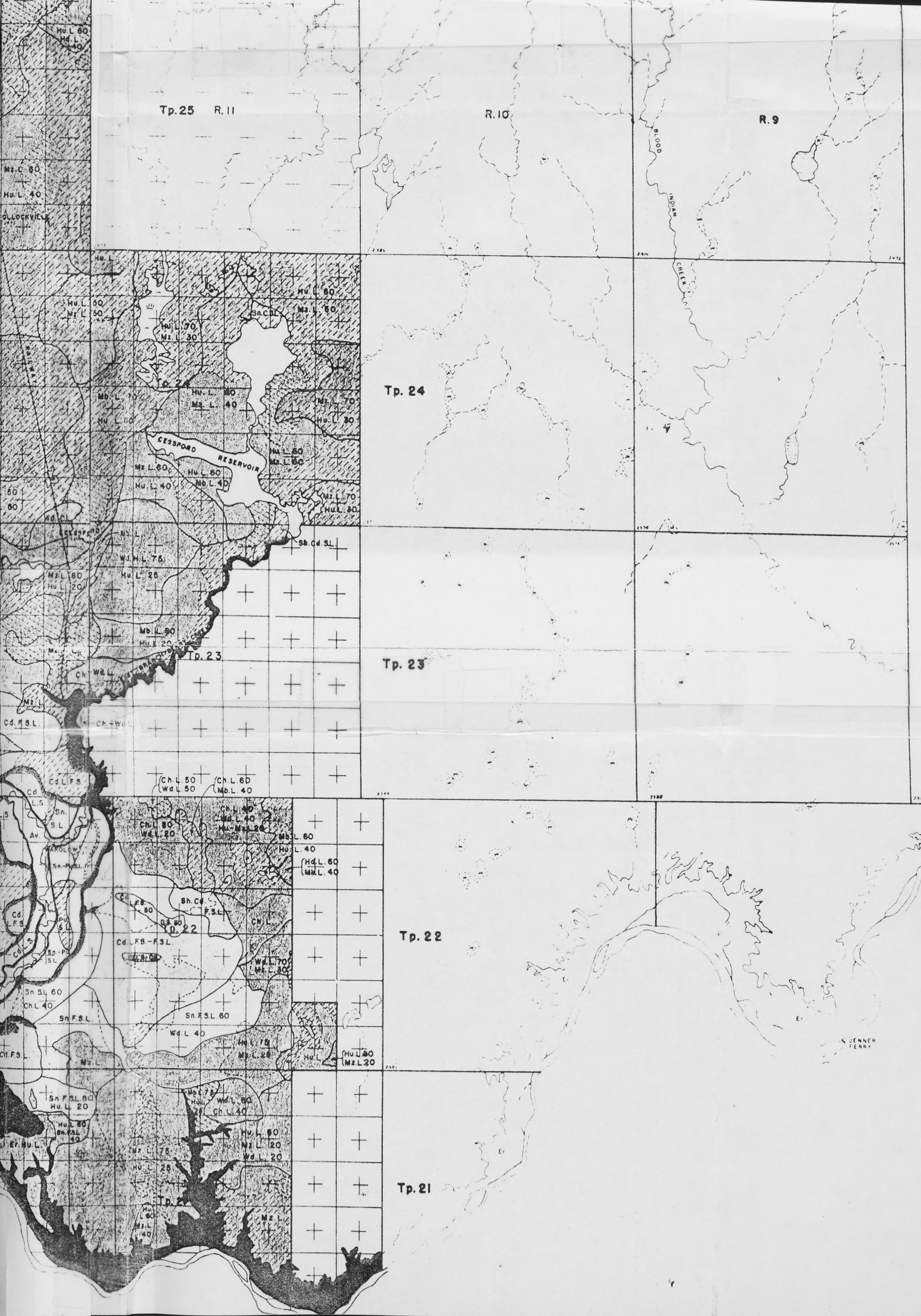
Er - Eroded - most of A horizon removed

St - Stony - surface stones exceed S3

Rough broken land adjacent to stream courses

Slough


R.13
R.12
POLLOCKVILLE
HUTTON FERRY
DEAD FISH CREEK
DEAD FISH CREEK RESERVOIR
RED DEER RIVER
Hu. L. 70
Mz. L. 30
Mz. L. 70
Wd. L. 30
Hu. L. 80
Mz. L. 20
Sh. Ch. L.
Sh. Ch. L. 50
Wd. L. 50
Pu. L.
Cd. S.L.
Ch. L.
Mz. L.
Cd. L. F. S.
Cd. F. S. L.
Sn. F. S. L.
Ch. V. F. S. L.
D. S.
Av.
Mb. L. 75
Hu. L. 25
Mz. L. 75
St. Hu. L.
Sh. Cd. F. S. L.
Sh. Cd. S. L.
Cd. L. S.
Sh. Cd. L. S. 50
Cd. L. S. 50
Cd. L. F. S.
Mz. L. 50
Wd. F. S. L. 50
Cd. F. S. L. - L. F. S.
St. Mb. L.
Hu. L.
Hu. L. 70
Mz. L. 30
Mz. L. 50
Hu. L. 50
Wd. L. 50
Hu. L. 50
Ty. L. 70
Wd. L. 30
Wd. L. 60
Ty. L. 40
Ty. L. 60
Ch. L. 40
Sn. L. F. S.
Cd. F. S. L.
Hu. F. S. L.
Wd. L. 50
Cd. L. S. - S. L. 60
Sn. S. L. 40
Mz. C. 60
Hu. L. 40
Sn. S. L. 60
Ch. L. 40
Sn. F. S. L.
Cd. F. S. L.
Sn. F. S. L. 80
Hu. L. 20
Er. Hu. L.
Mb. L. 70
Hu. L. 30
Hu. L. 60
Mz. L. 40



Tp.25
R.11
R.10
R.9
BLOOD INDIAN CREEK
POLLOCKVILLE
Tp. 24
CESSFORD RESERVOIR
Tp. 23
Tp. 22
Tp. 21
JENNER FERRY
Hu.L. 60
Wd.L. 40
Mz.C. 60
Hu.L. 40
Hu.L. 50
Mz.L. 50
Hu.L. 70
Mz.L. 30
Hu.L. 60
Mz.L. 60
Sn.Cd.L.
Mb.L. 70
Hu.L. 30
Mz.L. 70
Hu.L. 30
Hu.L. 60
Mz.L. 40
Mz.L. 60
Hu.L. 40
Hu.L. 60
Mb.L. 40
Hu.L. 60
Mz.L. 60
Mz.L. 70
Hu.L. 30
Wd.Cl.
Sb.Cd.S.L.
Wd.H.L. 75
Hu.L. 25
Mz.L. 80
Hu.L. 20
Mb.L. 80
Hu.L. 20
Ch.Wd.L.
Cd.F.S.L.
Ch.+Wd.L.
Cd.L.F.S.
Ch.L. 50
Wd.L. 50
Ch.L. 60
Mb.L. 40
Ch.L. 80
Wd.L. 20
Ch.L. 40
Wd.L. 40
Hu-Mz.L. 20
Mb.L. 60
Hu.L. 40
Hd.L. 60
Mb.L. 40
Sh.Cd.
F.S.L.
Ch.L.
Cd.L.F.S.-F.S.L.
Wd.L. 70
Mz.L. 30
Sn.S.L. 60
Ch.L. 40
Sn.F.S.L.
Sn.F.S.L. 60
Wd.L. 40
Hu.L. 75
Mz.L. 25
Hu.L. 80
Mz.L. 20
Sn.F.S.L. 80
Hu.L. 20
Er.Hu.L.
Mb.L. 75
Wd.L. 60
Ch.L. 40
Hu.L. 60
Mz.L. 20
Wd.L. 20
Mz.L. 75
Hu.L. 25